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ABSTRACT

This study formulated a multivariate model of early infant competence from variables representing a transactional perspective of developing competence in early infancy. The measures used in the competence model were: birth weight; habituation index; personality ratings of the infants' social orientation and task orientation; ratings of maternal responsiveness to infant distress and social signals; and measures of observed maternal latency of response to infant distress and vocal signals taken in the home. The sample consisted of 51 middle income white families with first born infants of normal birth weight and free of significant birth defects. The model was validated against the Bayley Scales of Mental and Motor Development, when the infants were 2 1/2 and 6 months old, using multiple linear regression analysis. Results are presented for infant and maternal variables which were found to be predictive of mental and motor development at 2 1/2 and at 6 months. Sex differences in patterns of results across time are also presented and discussed. It was concluded that the acquisition of early competence appears to involve the interplay of maturational, personality, and environmental events and that the infant's own characteristics appear to weigh heavily in his/her transactions with the environment in early infancy. (Author/JMB)

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Correlates of Early Infant Competence: A Multivariate Approach

By
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Final Report, Part I
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CORRELATES OF EARLY INFANT COMPETENCE: A MULTIVARIATE APPROACH

by

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A multivariate model of early infant competence was formulated from a transactional perspective that represented a progression from infant organismic status at birth to more distal measures of maternal responsiveness within the caretaking environment. The model was validated against external criteria: the Bayley Scales of Mental and Motor Development, when the infants were 2½ and 6 months old, using multiple linear regression analysis.

The sample consisted of 51 middle income white families with first born infants of normal birth weight free of significant birth defects. There were 26 females and 25 males in the sample.

The measures used in the competence model were: birth weight; habituation index; personality ratings of the infants' social orientation and task orientation; ratings of maternal responsiveness to infant distress and social signals; and measures of observed maternal latency of response to infant distress and vocal signals taken in a naturalistic setting, the home.

The research questions asked were:

1. Does the multivariate model of early infant competence account for a statistically significant proportion of the variance in the external criteria at 2½ and 6 months?
2. Do each of the predictor variables in the competence model contribute to the development of the competency system?
3. Can the external criteria be predicted over time using the multivariate model?
4. Are there sex differences in the emerging patterns of competency?

The principal results of the study demonstrated that:

1. A statistically significant proportion of the variance in external criteria was accounted for by the multivariate model at 2½ and 6 months;
2. Each variable does not contribute significantly to the competence model at each time period;
3. The model did not predict a statistically significant proportion of the variance in external criteria over time;
4. Patterns of differences exist between males and females in developing competency.

Specific results at 2½ months

Although birth weight, social orientation, and task orientation are significant correlates of mental development, task orientation, alone, is the most useful predictor of mental development. Task orientation, birth weight, and observed maternal latency of response to infant distress signals are the most useful predictors of motor development. The relationship between motor development and maternal latency measures indicates that longer maternal latency of response is associated with infant motor competence.

Specific results at 6 months

While the model accounts for less than half of the variance in the external criteria, task orientation continues to be the best single predictor of mental and motor development. Social orientation and the habituation index are predictors of mental development, while the habituation index, social orientation, and rated maternal responsiveness are useful in predicting motor development. Rated maternal responsiveness is negatively related to motor development, indicating a relationship between low rated maternal responsiveness and infant motor competence.

Observed latency of maternal response to distress was predicted from a model composed of infant and maternal variables at 2½ months. Infant motor competence was the most useful single predictor of maternal response.

The patterns of correlations by sex analysis indicated that the paths to competence may differ for males and females, but, more importantly, the time at which patterns emerge is different across sex.

The acquisition of early competence does appear to involve the interplay of maturational, personality, and environmental events, and, therefore, cannot be assumed to come from the organism alone or from the environment alone. In early infancy, the infant's own characteristics appear to weigh heavily in his/her transactions with the environment.

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Prologue

On competence:

In social life, there is much bitter truth to the biblical maxim, "to him who hath shall be given; from him who hath not shall be taken away even that which he hath." Launched on the right trajectory, the person is likely to accumulate successes that strengthen the effectiveness of his orientation toward the world while at the same time he acquires the knowledge and skills that make his further success more probable. His environmental involvements generally lead to gratification and to increased competence and favorable development. Off to a bad start, on the other hand, he soon encounters failures that make him hesitant to try. What to others are challenges appear to him as threats; he becomes preoccupied with defense of his small claims on life at the expense of energies to invest in constructive coping. And he falls increasingly behind his fellows in acquiring the knowledge and skills that are needed for success on those occasions when he does try (Smith, 1969, p. 215).

Introduction

The efficacy models of competence (White, 1959; Smith, 1969) serve as a theoretical framework for research related to the mechanisms for the development of competence. It has been acknowledged that the early experiences of the child provide a basis for the development of future competence in a number of areas (Bloom, 1964; Hunt, 1965). Piaget (1952) has pointed to the importance of infancy, as even the most basic reflexive behaviors "constitute an historical development so that each episode depends on preceding episodes and conditions those that follow in a truly organic evolution [p. 25]."

Bruner (1968) has observed that "when one examines infancy carefully, one is struck by the artificiality of analysis that is based upon the examination of isolated responses. Responses are parts of larger systems, and these larger systems are what require deeper study [p. 66]." In order to examine larger systems one must consider multiple variables relative to the child and his/her environment. Clarke-Stewart (1972) has discussed the need for the study of multiple variables to "reveal overall patterns of relationships [p. 60]." The use of multiple variables in studies designed to predict infant competence across time may enhance the poor predictive validity of early infant developmental scales. In a longitudinal study of the predictive validity of infant tests, multiple measures were used with a high degree of accuracy to predict later I.Q. (Knobloch and Pasamanick, 1966). Thomas (1967) noted that it is rare to find studies in which multiple correlation is used, and "further exploration of multiple regression techniques seems in order [p. 203]."

This study is an investigation of multiple measures reflecting the interaction between the organism and the environment in early infancy. The model of early infant competence includes measures of: birth weight as an index of status at birth; visual information processing (habituation); personality characteristics (task and social orientation); in combination with maternal/child interactional characteristics; maternal latency to distress, maternal latency to respond to infant vocalizations, and general responsiveness of the mother to the infant's behavior. These measures were used to form a model of early infant competence that was validated by testing it against an external criterion measure of competence, the Bayley Scales of Infant Development (Bayley, 1969).

Attempts to examine multiple characteristics of infants prior to 6 months of age and their relationship to maternal characteristics in relation to overall competence have been few. As there is theoretical support for continuity of development, (Smith, 1969), infants were examined at 2½ months and again at 6 months to determine if there are variables that account for significant proportions of the variance in infant competence both contemporaneously and across time. In order to minimize the possibility that parental education (Rutter, 1970) or social class (Lewis, Goldberg & Campbell, 1969) alone would account for the variance, a homogeneous group of white, healthy, full-term, hospital born infants free of significant birth defects were selected. This group of infants consisted of nearly equal numbers of males and females.

The following sections include a discussion of the external criterion variable, intelligence, and its relationship to competence, and the rationale for inclusion and selection of predictor variables to be used within the theoretical framework of an efficacy model of competence.

Intelligence

At the turn of the century psychologists showed little interest in the notion of intelligence, and Spearman (1927) observed that a large number of psychology books did not even mention "intelligence." However, over the next half century much research activity has been directed at defining the construct of intelligence. Binet and Simon (1908) generated much of this interest with the publication of "Le development de l'intelligence chez les infants." Their focus was not on what intelligence was but, rather, on how intelligence could be measured (Wechsler, 1958). Terman (1916) adapted, revised, and standardized the Binet scales and introduced them in the United States, where they continue to be used as the Stanford Binet Intelligence Scales (Terman and Merrill, 1937; Terman and Merrill, 1960). There scales have as a central notion that "general intelligence is a trait which develops with age (Terman and Merrill, 1960, p. 7)." This view of intelligence assumes a unitary "trait" that is stabile across time with possible genetic origins. At about the same time that the Binet scales were introduced, Spearman (1927) used correlational techniques to identify a "g" factor common to all intellectual abilities, and "s" factors common to some specific abilities. The construction of the Binet scales is based on the "g" factor conception of intelligence.

E. L. Thorndyke (1914) was one of the first twentieth century psychologists to suggest subcategories of intelligence: abstract/verbal intelligence; practical intelligence; and social intelligence. Alexander (1935) demonstrated that after the "g" factor and several other factors (primarily verbal and practical ability measures) were eliminated, a considerable amount of the total variance was not yet accounted for. Alexander attributed the remaining variance to factors such as: interest in doing tasks; "persistence in attacking them"; and zest and desire to succeed (Wechsler, 1955, p. 14). Wechsler (1944) has referred to these factors as the "non-intellective factors" relating to intelligence.

During the first half of the century the notion of intelligence has evolved, aided by the evolution of statistical techniques, notably factor analysis, from a unitary construct to a construct that recognizes multiple factors (Guilford, 1956, 1959; Thurstone & Thurstone, 1941). Additional (non-intellective) factors that are not necessarily measured by specific test items have also been recognized as contributing to "intelligence."

Another important development in the construct of intelligence is the investigation of the etiology of intelligence. When intelligence was considered to be an "inherited, stable, and general capacity" (Bayley & Schaefer, 1964, p. 5) its etiology was considered to be largely inborn or genetic, i.e.:

> Intellectual development was considered to be mainly a process of maturation that would resist change except

> under extreme conditions [Gallagher in Hoffman & Hoffman, 1964, p. 350].

A number of developments within the field of psychology, particularly in the United States, have brought the genetic approach to intelligence into question. One of the first of these developments was Watson's (1924) stance against genetically determined behavioral development, and for environmental contributions to the behavior of the organism. Bloom (1964), after an extensive review and reanalysis of developmental data, summed up the more recent notions of environmental impact on the development of the construct of intelligence especially in early childhood:

> . . . we would question the notion of an absolutely constant I.Q. Intelligence is a developmental concept, just as is height, weight, or strength. There is increased stability in intelligence measurements with time. However, we should be quick to point out that by about age 4, 50% of the variation in intelligence at age 17 is accounted for. This would suggest the very rapid growth of intelligence in the early years and the possible great influence of the early environment on this development.
>
> We would expect the variations in the environments to have relatively little effect on the I.Q.

> after age 8, but we would expect such variation to have marked effect on the I.Q. before that age, with the greatest effect likely to take place between the ages of about 1 to 5 [p. 68].

Bloom (1964), Hunt (1961), Kirk (1958), Lee (1951) and others have been instrumental in providing data for the more recent investigations of environmental contributions to developing intelligence especially in the earliest years of life.

One of the primary contributors to the more recent thinking on infant intelligence is Nancy Bayley. The Berkeley Growth Study has produced evidence to indicate that I.Q. is not constant from birth to maturity (Bayley, 1955). (The Fels Research Institute's longitudinal study produced results regarding I.Q. constancy similar to Bayley's [Sontag, Baker, & Nelson, 1958], and, additionally demonstrated a close relationship between non-intellective characteristics involving motivation and personality that differentiated children whose I.Q.'s improved from children whose I.Q.'s decreased over time [Kagan, Sontag, Baker, & Nelson, 1958].)

In 1927, Nancy Bayley and her associates began the Berkeley Growth Study, a longitudinal study that involved measuring children's intellectual development repeatedly from infancy to adulthood. The study continued until 1957.

The sampling used in this study consisted of 61 "white, full term, healthy, hospital born babies of English speaking parents, whose mothers were willing and able to bring them in for monthly measurements [Jones, Bayley, Macfarlane, & Honzik, 1971, p. 12]." From this study the Bayley Scales of Infant Development were constructed, but more importantly, Nancy Bayley advanced a notion of developing intelligence that is not constant, or stable, or necessarily inborn:

> Intelligence appears to me, rather, to be a dynamic succession of developing functions, with the more advanced and complex functions in the hierarchy depending on the prior maturing of earlier simpler ones (given, of course, normal conditions of care) [Bayley, 1955, p. 807].

Bayley further explained the multiplicity of skills and abilities and their independence from each other as they enter into the development of manifest intelligent behavior in the young infant:

> The neonate who is precocious in the developing of simpler abilities, such as auditory acuity or pupillary reflexes, has an advantage in the slightly more complex behaviors, such as (say) turning toward sound, or fixating an object held before his eyes. But these more complex acts also involve other functions,

> such as neuro-muscular coordinations, in which he may not be precocious. The bright one-month-old may be sufficiently slow in developing these later more complex functions so as to lose some or all of his earlier advantage. This is the kind of thing that does seem to happen. Scores on tests given a month apart are highly correlated, but the longer the time interval between these baby tests the lower the interest correlation [Bayley, 1955, pp. 807-08].

To measure these diverse behaviors that are assumed to manifest the development of intelligent behavior, Bayley has chosen items for inclusion in the Infant Scales that include:

> evidences of the child's awareness of his environment and of his efforts to adapt to, manipulate, and alter it. At first these awarenesses are evidenced through his sensory reactions and the span of his attention to stimuli (visual, auditory, tactile, proprioceptive), and they are limited in part by the adequacy of his muscular strength and coordinations. With development, and more clearly in the "Pre-School Mental Scale," there is increasing evidence of learned behaviors, of expectancies, of relating objects exploitively, of goal-directed actions, of problem solving, of use of information,

> and of increasingly complex cognitive and intellectual processes [Bayley & Schaefer, 1964, p. 15].

Bayley's approach to mental measurement is somewhat like Binet and Terman's in that it focuses on the more pragmatic aspects of measurement of what is assumed to be intelligent behavior, rather than measuring theoretically defined cognitive functions. Bayley did not begin her measurement work with a theory that proposed to define the etiology of intelligence or to test particular constructs:

> The items finally included in the California First Year Mental Scale were selected after analysis of their adequacy according to the usual criteria. These criteria include: their occurance in all of or most of the infants; the increasing percentage of success on them with increasing age; for appropriate developmental stages; their internal consistency and correlation with the total behavioral criterion; and their apparent relevance as intellectual, adaptive, functions [Bayley, 1955, p. 806].

Bayley's work does, however, raise significant questions as to what accounts for developmental changes in intelligence. She points out several non-intellective factors that influence this inconstant development:

> It is now well established that we cannot predict later intelligence from the scores on tests made

> in infancy (Anderson, 1939, Goodenough, 1949). Scores may be altered by such conditions as emotional climate, cultural milieu, and environmental deprivation, on the one hand, and by developmental changes in the nature and composition of the behaviors tested, on the other [Bayley, 1955, p. 806].

More recent research has been aimed at defining the contribution of these non-intellective and possibly other cognitively linked factors to the development of intelligence in infants, while cognitive theorists have advanced notions regarding the etiology of intelligence (Piaget, 1952; Werner, 1957). Currently the most accepted notion regarding the etiology of intelligence is one that views an organism-environment interaction or transaction as the basis for the development of intelligent behavior (Piaget, 1952). Theories vary in relative amounts of the variance attributed to the organism as opposed to the environment:

> . . . The etiology of intellectual functions is another aspect of intelligence which has been the subject of much theoretical controversy. In general the trend in the past fifty years in theories of intelligence has been from the assumption of an inherited, stable, general capacity, toward an increasing complexity of multiple factors, whose

> development and manifestations are determined by inheritance alone, environment alone, or, more realistically, by some combination of the two [Bayley & Schaeffer, 1964, p. 5].

A definition of the etiology of intelligence that gives credence to the contributions of both the organism and its environment in equal measure is that of Escalona and Moriarity (1961):

> Intelligence is the result of a continuous stream of transactions between the organism and the surrounding field, which is the sum total of physical and social environmental conditions. . . . Since the organism brings to each adaptive act certain properties, both those of an intrinsic biological nature and those which are the result of the impact of previous experience upon the oranism, it is correct to say that intelligence development is at all times dependent upon what the organism is like. Yet it requires environmental circumstances to mobilize the organism, and since the kind of transition which develops depends on the objective content of that to which the organism must adapt, it is equally true to say that the development of intelligence depends at all times on the experience encountered by the

growing child [Escalona & Mariarity, 1961, pp. 598-99].

It is clear that not only the child's responses but also his organismic state and the objective content of his surrounding environment is a necessary focus for the developmental study of intelligence.

While advancing a notion of multi-factored intelligence, Wechsler (1958) operationally defined intelligence as "the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment [p. 7]." This type of notion transcends the adaptation level of behavior proposed by Escalona and Moriarity (1961) and adds the notions of purposeful and effective behavior to the concept of intelligence. When intelligence is defined that broadly it is difficult to consider it separately from a more general notion of competency.

Summary. During the past half century the construct of intelligence has evolved from the notion of stability over time to one that is at least in part dependent on the transactions between the organism and the surrounding environmental milieu. The acknowledged etiology of intelligence has changed from genetic attribution to a still somewhat vague entity that is constructed from an organism-environmental interaction or transaction. An important research question is, what is the nature of the interplay between the environment and the organism leading to the development of intelligence especially in the very young child?

Competence

McCall, Appelbaum, and Hogarty (1973) have defined I.Q. scores as "a sampling of behavior that lives or dies as a function of its practical utility in correlating with other behaviors of a sizeable segment of the population [p. 73]." In their argument against a "pervasive, unitary, and constant conception of intelligence [p. 73]," they point to the failure of infant tests to predict childhood I.Q. (McCall, Hogarty, & Hurlburt, 1972), and to the independence of performance on some tests from performance on others (Guilford, 1967).

While it has been well documented that infant I.Q.'s are poor predictors of later I.Q. (Bayley, 1940, 1955; Bloom, 1964; Thomas, 1967), there is a body of theoretical information that presents the position that while intelligence may not be constant throughout life, there is some form of competency that is consistent across age and has its roots in infancy (White, 1959, 1960, 1963). Smith (1969) has proposed that the constant factor across age may be intrinsic motivation as, "there is reason to expect continuities in intrinsic motivation even when there is discontinuity in the organization of intellective functions. Intuitively such continuity makes sense [p. 234]." In the White and Smith models, competence is acquired as a result of positive feedback received by the individual from the environment in response to his actions.

Smith's model of competency is based on a "sense of efficacy or potency" and an "attitude of hope [p. 219]." Competency evolves when: "The self is perceived as causally important, as effective in the world--which is to a major extent a world of other people--as likely to bring about desired effects and accepting responsibility when effects do not correspond with desire." The attitude of hope "provides the ground against which planning, forbearance, and effort are rational [p. 219]."

Smith's notion of competency resembles, in infancy, the first stage of development proposed by Erikson (1963) in which the infant establishes a pattern of relationships based on basic trust. This sense of trust is established through the interactions of the infant with the caretaker, the mother:

> The infant's first social achievement, then, is his willingness to let the mother out of sight without undue anxiety or rage, because she has become an inner certainty as well as an outer predictability.

> Such consistency, continuity, and sameness of experience provide a rudimentary sense of ego identity which depends, I think, on the recognition that there is an inner population of remembered and anticipated sensations and images which are firmly correlated with the outer population of familiar and predictable things and people [Erikson, 1963, p. 247].

Erikson's notion of trust is also built on a feedback system established by the child as a result of his early experiences with his caretaker. The child "learns" to "trust" the world in which he lives when his inner needs and experiences are responded to in a consistent and predictable manner by the caretaker. From this consistent balance between inner needs and outer world, the infant develops the sense of himself that is "firmly correlated" with sets of images, sensations, and anticipated responses from the environment.

One of the ways a young organism is able to influence his environment is to act and to have the environment respond to his actions. This can be done in the sphere of materials (Piaget, 1952; Yarrow, 1972) or in social interactions (Erikson, 1963). According to Piaget, (1952) the infant interacts with his environment to form schemas which become more differentiated and mature as the child continues his interaction with the environment. The social interaction position hinges on the maternal-child relationship.

> What seems to get established very quickly between infant and parent is some sort of code of mutual expectancy. It seems to get established when the adult responds to an initiative on the part of the child, thus, converting some feature of the child's spontaneous behavior into a signal. Ainsworth (1967), Sander (1962, 1964), Freeman (1967), and David (1967) have all described this pattern of endowing the child's response with signal properties by linking the infant's initiative with adult response until such a time as the child performs an act with the expectancy of obtaining the adult response [Bruner, 1967-1968, p. 57].

Lewis and Goldberg (1969) have based their notion of the development of "generalized expectancy" on contingent social interactions in early infancy. These interactions between the infant and mother are capable of being generalized to later adaptation and learning:

> . . . contingency is important, not only because it shapes acquisition of specific behaviors, but because it enables the child to develop a motive which is the basis of all future learning. The

> main characteristic of this motive is the infant's belief that his actions affect his environment [Lewis & Goldberg, 1969, p. 82].

The set of expectencies that the infant develops may be very clearly related to the non-intellective factors that have been proposed to account for a sizeable proportion of the variance of I.Q.'s between ages, and may help to explain some of the variance that has not been accounted for previously by merely sampling infant intelligence or developmental performance over time. It has already been proposed that interaction of the infant-mother dyad may account for the development of some expectation that may become manifest in the behavior of the infant over time. The child's apparent zest for performing some tasks may be an index of his expectation regarding his potency in effecting change in his environment.

On the other hand, if the growth of competence or intelligence also assumes an interaction between the organism and his environment, some attention should also be paid to the initial status of the organism. An important question is that of determining the relative contribution of the infant's own capacity for adaptation as evidenced by his initial physical status as well as of some possible information processing mechanisms that appear to be "innate or maturationally determined" and not explained entirely by environmental interaction.

The present study involved the selection of certain variables that may serve as indices of the various contributions that environmental and organismic variables make to the prediction of the growth of competency or intelligence. It is apparent that as the notion of intelligence has become more complex and interactional, there is much overlap between the notions of intelligence and competency. When intelligence began to be regarded as not merely adaptive, but also as purposeful and producing effective interactions with the environment (Wechsler, 1968), the construct of intelligence became one not entirely linked with cognitive capacity alone, but, rather, one more closely associated with a general notion that involves the individual's ability to have impact on his environment, e.g., competence. Therefore, the criterion measure of competence to be used for the purposes of this study is the infant's performance on the Bayley Scales of Infant Development (Bayley, 1969). These scales were chosen because they present to the infant a wide variety of age appropriate tasks to which the infant may respond with a broad range of behaviors. In addition to the range of behavior that can be elicited by the scale, normative data has been carefully compiled on a large (n = 1262) number of infants who represent varying backgrounds.

Birth Weight

The use of birth weight as a predictor variable in developmental research has been largely confined to research on pathological populations to assess such conditions as the effects of prematurity on performance. To the extent that birth weight is dichotomized as being within the normal or sub-normal range, it has been considered to be an index of the condition or status of the infant at birth. In pediatric research birth weight has been used to predict mental and motor development in infants considered to be premature (birth weight less than 2501 gm.) (Wiener, Rider, Wallace, Oppel, Fisher, & Harper, 1965). In several studies of low birth weight infants (Berendes, 1964; Robinson & Robinson, 1965; Wiener, et al., 1965), birth weight has been shown to "have a major effect on neonatal condition and future performance [Singer, Westphal & Niswander, 1968, p. 109]." However, birth weight in combination with socioeconomic status (Robinson & Robinson, 1965) and birth weight in combination with a diagnosis of minimal neurological dysfunction (Winer, et al., 1965) were reported to be better predictors of later development than birth weight alone. In a population "relatively free of severe pathology" (Wiener, et al., 1965) found birth weight to be the "most significant correlate of motor development (p. 438), as measured by

Bender-Gestalt reproductions (perceptual motor behavior) and "Thinking mode" (p. 441) in school aged children when low birth weight children were compared with matched samples of children having normal birth weight.

Studies of twins have also used birth weight as a predictor variable. The rationale for these studies is to determine the effects of intrauterine growth retardation between twins who are discreptent in birth weight but who have a common gestational age, racial background, maternal health and nutrition, and, in monozygotic twins, genetic factors (Babson, Kangas, Young, Bramhall, 1964). The heavier members of monozygotic and dyzygotic twin pairs have been found to have significantly higher measured intelligence at school age (median age at measurement = 8½ years). It was concluded that these findings support the notion (Bowen & Hepner, 1959; Engleson, et al., 1963) that: "intrauterine growth retardation is associated with retardation of subsequent growth [Babson, et al., 1964, p. 332]." Mother rated behaviors of their twin infants revealed that the heavier member of the twin pairs vocalized better when the difference in birth weight between twin pair members was slight, and when the difference in birth weight was 1.5 pounds or more, the lighter child exhibited more problem behaviors related to sleeping, eating, toilet training, irritability, and temper. The heavier member of the twin pair was rated significantly higher in attention span, vocalization, which were regarded as rudimentary cognitive processes; adaptability; and expressing affection (Matheny & Brown, 1971). While some of these behavioral differences may be related to postnatal development:

> Behavioral differences between twins certainly have been found to be influenced by postnatal environmental factors. The possibility that some of these differences may be products of the prenatal environment should not be overlooked, however. When birth weight is related so strongly to some behavioral differences, the postnatal environment may serve only to amplify, by contrasting demands of the infant on caretaking activities and the like, differences already existent at birth [Matheny & Brown, 1971, pp. 256-57].

In a study of primarily lower socioeconomic status infants who had low (5 and below) Apgar ratings (Apgar, 1953) matched for birth weight, race, and sex, with children with high Apgar ratings (rating = 10), birth weight correlated significantly for boys with a sub scale of a multifactored intelligence test (Pacific Multifactor Test, Meyers, et al., 1964) and with the Vineland Social Maturity Scale (Doll, 1953) administered at 30 months of age (Shipe, Vandenberg & Williams, 1968). Brown, Bakeman, Snyder, Frederickson, Morgan, and Hepler, 1974, using a lower socioeconomic status Negro population, found that mothers vocalized more and showed more affection toward their heavy male neonates, suggesting the possibility of an interactional environmental advantage that heavier male infants have from birth, which may partially explain the findings of Shipe, et al. (1968).

In an exploratory study, Smith, Flick, Ferriss, and Sellmann (1972) assessed the relationship between prenatal, perinatal, and postnatal variables to predict or classify cognitive performance at ages 4 and 7. The population consisted of lower socioeconomic status Negro children whose mean birth weight was within the normal range ($\bar{X}$ = 2991.9 gr., s.d. = 483.56 gr.). When a number of variables were used to predict cognitive performance at ages 4 and 7, birth weight continued to be a useful predictor variable through age 7. They further found that the usefulness of variables measured during the first year of life to predict psychological status at 7 years "does not increase greatly with the addition of developmental information collected between 1 and 4 years of age [p. 504]."

In non-pathological samples of infants there is little evidence linking birth weight (considered here as an index of the child's condition at birth and of quality of prenatal environment) to subsequent development, although there is a great deal of evidence to consider birth weight as a good predictor variable in low birth weight populations, or in twin populations when the weight of one member of the twin pair is discrepant (more than 1.5 pounds) from the weight of the other twin pair member. Babson, Henderson, and Clark (1969) cite the paucity of research available on the intelligence of children who are considered high birth weight (weight over 4100 gm.), although there is some indication that slightly more defects occur in extremely high birth weight infants (weight over 10.25 lbs) (Asher & Roberts, 1949). As very high birth weight can be associated with maternal diabetes, either overt or latent, or transposition of the fetal aorta (Lubchenco, Housman, & Boyd, 1966), it can be indicative of a pathological condition. A longitudinal study of gifted children who continued to be exceptional achievers as adults produced evidence that this population also deviates in birth weight from what is considered normal. One of the findings of Terman's Genetic studies of genius (1925) was that:

> The mean birth weight was approximately three-fourths of a pound above the norm according to accepted standards. This excess amounts to three-fifths of the standard deviation of the birth weight of the gifted [p. 211].

The question is, then, one of assessing the effect of birth weight (as an index of the infant's state of birth) on the performance of singly born infants whose birth weight falls within a normal range (non-premature). The prenatal environment that can contribute to variations in birth weight include some of the following factors: genetic-socioeconomic status; maternal nutrition; chemical toxins; maternal endocrine functions, such as diabetes, mellitus, or the ingestion of potent hormones, and possibly to age of parents; infections; maternal-infant blood incompatibility; and faulty placental function (Lowrey, 1974). If birth weight can be used as a predictor of level of competence in infants who are below normal in birth weight, and if relatively high birth weight is one of the characteristics of infants who become extremely high achieving adults, what is the relative contribution of birth weight to performance in a sample of infants who have a range of birth weights within the normal range?

Wiener et al. (1965) have pointed to the need for a multivariate approach to determining the relative variance accounted for by birth weight using low birth weight samples:

> Results presented demonstrate the significant relationship of several psychological variables with birth weight. What has not been mentioned is the degree of this relationship: what proportion of the

> variance in psychological functioning is associated with birth weight and correlated indices of neurological damage when social class, maternal attitudes, and race are controlled [Wiener, et al., p. 440].?

The same question and methodology could be adopted using a population of infants considered to be "normal" (birthweight between 2500 gm and 4100 gms.) to determine what proportion of the variance in infant competence is accounted for by birth weight in a group of infants who have common racial and social class backgrounds. Does the "well nourished" neonate enter the world with advantages enhanced by the possibility of having had an enriched prenatal environment?

Habituation

One of the variables that has been used to distinguish between full-term and low birth weight infants (birth weight less than 5 pounds, 8 ounces) who were matched for conceptual age and examined at 19 weeks, is response to visual stimuli. Sigman (1973) reported that low birth weight infants responded less well to novel stimuli than full-term infants, and they did not "manifest the same visual preferences." Full-term infants looked longer at photographs of faces rather than scrambled features within a facial contour than did the low birth weight infants. Both groups of infants were equally able to assimilate edge information, and the author concluded:

> Even the preference for face-like stimuli implies the kind of memory processes involved in schema formation. The evidence that premature infants showed no distinction between novel and familiar stimuli nor between regular and scrambled faces may indicate that a cognitive, memory function is distorted [p. 11].

These findings may be somewhat better understood in terms of Bronson's (1974) proposed evolution of visual systems. The initial system Bronson proposed that is used by the neonate is the "phylogenetically older" second visual system which functions to:

> . . . include the smooth tracking of a moving visual field and the tendency to shift the eyes to bring a salient peripheral stimulus into foveal regard; those parts of a pattern falling within the macular area are unattended due to the general immaturity of the primary visual system. It is doubtful that the newborn is responsive to the complex configurational attributes of a stimulus array [p. 887].

Bronson further proposes that the visual system develops during the second month to:

> . . . permit an infant (a) to focus his attention on discrete foveally located stimulus elements, and

> (b) to begin dimly to encode the more salient components of repeatedly experienced patterns and to form associations to them. . . . But the infant's gaze continues to be captured by salient contour, and therefore only limited aspects of a stimulus configuration will be attended to and hence encoded [p. 887].

About the third month, because of increased ability to "utilize prior experience for the guidance of visual regard" (memory), the system further develops to permit the infant to be free from limiting his visual regard to the "most salient aspects of the configuration," and to be able to:

> . . . examine diverse aspects of a stimulus in a series of repeated refixations, and the development of this intentional scanning enables the infant to encode entire patterns where previously only isolated elements were recorded.

The primary visual system is then functional by about two to three months of age, and the infant is able to utilize prior visual experience to gain some control over his processing of visual images:

> . . . the accretion of visual memories within the final states of the conceptual model permits the volitional control of visual regard, and with this

> development, the infant becomes an internally directed, historically guided, pattern organizing individual [Bronson, 1974, p. 887].

This evolution in the visual system may mark the beginning of the infant's ability to exert some degree of control over the visual stimulation within his environment.

Habituation is a process frequently studied in young infants. It has been considered to be a reflection of early learning (Bartoshuk, 1962; Engin & Lipsitt, 1965; Fantz, 1964) and unlearning a response (Thompson & Spenser, 1966). Habituation has also been considered to be a "useful tool" for studying memory functions (Kessen, Haith, & Salapatek, in Mussen, 1970, p. 341), and for studying information storage capacity (Fantz, 1964; Lewis, Bartels, Fadel, & Campbell, 1966; Pancratz & Cohen, 1968). "Since habituation may predate positive learning in that it does not require the occurrence of a new response, habituation may provide an index of early learning [Kessen, et al., in Mussen, 1970, pp. 341-42]." Habituation does appear to provide some index of the earliest efforts of the infant to exert some measure of control over the "blooming, buzzing, confusion" that is inherent in his perceptual environment. Because these beginnings of control allow the infant to affect his/her environment, habituation is also related to an efficacy model of competency.

Bronson's model is descriptive of normal growth and development, and can be used to distinguish adults and animals (see Bronson, 1974) who are neurologically deviant from the norm, by virtue of brain leision, etc. When Sigman's (1973) results are considered in light of Bronson's developing visual systems, possibly differences in developmental patterns related to the stage of development of visual systems differentiate the low birth weight infants from those who are full-term. Sigman's premature (possibly less mature) infants may be utilizing a prior stage of development in visual systems in their undifferentiated regard for scrambled features as opposed to faces, and redundant as opposed to novel stimuli.

Bayley (in Mussen, 1970) has proposed that "characteristics such as drive, perseverence, and attention span," which may include measures of attending to visual information, could be "in varying degrees genetically determined," and "may operate to enhance or retard the development of mental abilities [p. 1201]." As Bronson (1974) has posited, the infant's ability to regard visual stimuli may follow a sequentially ordered developmental pattern, and to that extent, the boundaries of visual information processing may be maturationally determined. However, Bronson (1974) does not exclude the possibility of visual development being enhanced by organism/environment interaction:

> . . . rather than conceiving of postnatal change as reflecting a general improvement in the efficiency of a total system all of whose components are to some degree functional from birth, it seems more nearly correct to posit the emergence of a series of new capabilities corresponding to the progressive development of increasingly more sophisticated neural networks. Furthermore, . . . it is moderately well established that these various neural developments, if they are to be normal, require appropriate forms of visual stimulation (e.g., Hirsh & Spinelli, 1970; Hubel & Wiesel, 1970; Pettigrew, 1972) [Bronson, 1974, p. 887].

The development of the infant's ability either maturationally or in interaction with his environment to control incoming visual stimulation and to encode it appears relevant to the more general issue of developing competency. Although Hunt (1965) views the mechanisms for such control as inherent in the neonate, he makes the point that "intrinsic motivation" has its roots in early infancy and forms the basis for continued motivational factors in the infant's learning to learn:

> In this first stage of intrinsic motivation, the standard of reference against which new receptor

> input becomes incongruous is the ongoing input of the moment. . . . This responsiveness to change in input, especially through the eyes and the ears, indicates that a basis for motivation inherent in the infant's informational interaction with his circumstances exists, ready-made, even at birth [Hunt, 1965, p. 232].

Smith (1969) and Bower (1966) have discussed the important contribution to the infant's acquisition of perceptual competency of responses made by the infant to his visual environment. Held and Hein (1963) also suggest that kittens learn to perceive as a result of their own responses to the perceptual field.

One of the ways a young infant, and possibly a neonate (Friedman, 1975), can demonstrate control over repeated visual stimulation from the environment is through adaptation, inhibition, stimulus satiation, habituation (Jeffrey & Cohen, 1971), or the orienting reflex (Pavlov, 1947-1949; Sokolov, 1963). These terms are used to describe decrements in the infant's response to repeated or redundant stimuli, "not accounted for by peripheral mechanisms such as receptor or effector fatigue [Lewis, Goldberg, & Campbell, 1969, p. 1]." These measures of response decrement to redundantly presented visual stimuli have been assumed to be indexes of information processing in the infant. Jeffrey and Cohen (1971) and Razran (1961) contain theoretically relevant reviews of habituation literature.

The model used to describe the orienting reflex was proposed by Sokolov (1963) and is based on neuronal acquisition of stimulus patterns:

> Sokolov's (1963) model interprets response decrement in terms of neuronal model acquisition, a model being an organization of neural cells which process and store stimulus information. When a stimulus is presented repeatedly, each occurrence is the occasion for comparison of the stimlus with the model. When the stimulus does not match the model or the model is not fully articulated, central excitation takes place, an orienting reflex (attention to the stimulus) occurs, and the model is strengthened or elaborated. If the stimlus and the model match, negative feedback results in the absence or decrease of the orienting response. Thus, a progressive decrease in attention with each repetition is indicative of model acquisition [Lewis, Goldberg, & Campbell, 1969, p. 3].

Based on the notion that information is processed and responded to in this manner, response decrement to repeatedly presented visual stimuli (habituation) has been assumed to be an index of information processing in the infant.

If habituation is related to central processes (Lewis, et al., 1969), a relationship between this type of information processing and other cognitive variables may exist, and if the construct of habituation has stability within infants over time, early competency in visual information processing may be useful in predicting competence in later cognitive development. Lewis considers this the "most interesting use" that could be made of response decrement scores:

> It does seem clear that response decrement of behaviors associated with the active taking in and processing of visual information, such as fixation and cardiac deceleration, is related to cognitive capacity, and developmental organization [Lewis, et al., 1969, p. 36].

Lewis et al. (1969) have related habituation to concept formation tasks with 44 month old children ($n = 20$, $r = .37$, $p = .05$) and to a discrimination learning task ($n = 32$). Magnitude of response decrement was associated with fewer errors on the learning task, while response decrement discriminated between those subjects who could and could not solve the problem presented. Lewis (1967) has also reported that response decrement at one year of age (n = 40) predicted Stanford Binet I.Q. measured at 44 months. In another study, Lewis, Bartels, Campbell, and Goldberg (1967) have related magnitude of response decrement at 13 weeks to neonatal APGAR scores (Apgar, 1966). Similar findings using cardiac deceleration as a measure of response decrement to auditory stimuli were reported by Eisenberg, Coursin, and Rupp (1966) and discriminated between premature and full-term infants. Polikania and Probatova (1958) also found slower habituation to an auditory stimulus in premature infants as compared with more rapid habituation in full-term babies. Conway and Brackbill (1969) found neonates whose mothers were medicated during labor and delivery showed significantly less habituation than a non-medicated group for up to one month after birth.

Several investigators have found that younger infants habituate more slowly than older infants (Fantz, 1964; Lewis, et al., 1969; McGurk, 1972). Rapid habituation has been linked with parental education (McCall, 1972): more rapid habituators at 12 weeks of age had more highly educated parents than slow habituators.

Stechler and Carpenter (1967) have referred to the mode an organism uses to regulate stimulation encountered as "autoplastic" where the mode does not "alter the environment but rather alter(s) the perception of it [p. 185]." Adapting to visual stimulation by means of habituation would be an autoplastic mode. Another mode for regulating the environment through social interchange with the caretaker is characterized as being "alloplastic." Both of these modes of behavior gave the infant "more active control over external input [Friedman, 1975, p. 28]" and would relate to an efficacy model of developing competency. Measurement of allopastic modes will be discussed in the following sections.

A question that could be explored through a multivariate model is: does habituation generalize to form a basis for later cognitive competence? One way to use habituation to predict individual competencies would be to look at the stability of response decrement over time with the same group of infants. The time period may be critical in terms of maturation of visual systems. Does the construct have some stability within individual subjects, or does change in habituation occur related to maturational changes in the visual systems? There is evidence to support the notion that visual information processing, operationally defined as habituation, changes as infants mature, however, we know little about intra-subject variability or possible sex differences relative to the construct over time.

Personality Variables Based on Behavioral Ratings

Consistent with the notion that competency has its roots in infancy and that early competency may be related to characteristics established during the first year such as intrinsic motivation (Hunt, 1965), basic trust (Erickson, 1963), or efficacy (Smith, 1969), several efforts have been made to relate various infant personality characteristics to later competence. Research in this area is beset with problems in terms of the measurement of characteristics:

> The variability in instrument and procedure that characterizes longitudinal studies of motor and mental development is, not surprisingly, of a low order when compared with studies of early personality. We have some sense of what adult intelligence is and how to assess it; we have only a beginning notion of the dimensions of adult personality. Studies of infantile personality share an interest in some large categories (e.g., activity, impulsivity, and social response, particularly dependency and aggression) but there appear to be no two studies in the literature where the same instruments and the same procedure for personality assessment were used [Kessen, Haith, & Salapatek, 1970, p. 308].

Terman and Oden (1947, 1959) reported that the children labeled as "geniuses" when followed longitudinally could be differentiated into groups of successful versus non-successful on the basis of childhood personality ratings of self-confidence, perseverence, goal directedness, and the absence of feelings of inferiority (Hoffman & Hoffman, 1964). Similar findings were reported for the Fels longitudinal study of children who exhibited I.Q. gains over time (Sontag, Baker, & Nelson, 1958). Using longitudinally collected data from the Berkeley Growth Study, Bayley and Schaefer (1964) correlated behavioral ratings made during developmental examinations (Bayley, 1970) such as social, emotional, and task oriented behaviors with concurrent and longitudinally sampled intelligence test scores. The ratings were made at intervals from 10 months to 18 years. The findings indicated that "more social-oriented babies tend to make higher intelligence scores in the first two years, and lower scores after five years. The pattern seems clearer for girls [p. 37]." Activity level of the babies was found to correlate positively with intelligence measured on the Bayley Scales of Infant Development (Bayley, 1969) between 4 and 36 months, however, these ratings were negatively correlated with intelligence measured after three years. McCall, et al. (1972) report findings similar to the Berkeley Growth Study findings for the Fels longitudinal study data, i.e.: that

> . . . while social facility and extraversion are related to high scores for both sexes during

> childhood and adolescence, male infants who are rated as happy, positively responding, and calm prior to 15 months have high infancy scores but relatively lower I.Q.'s by age 4 [McCall, Appelbaum, & Hogarty, 1973, p. 8].

McCall, et al. (1973) conclude that "there are personality correlates of I.Q. level during childhood and that the pattern of relationships may be different as a function of age and sex [p. 8]."

Freedman and Keller (1963) were able to differentiate between fraternal and identical twin pairs by measuring personality characteristics with the Infant Behavioral Record (Bayley, 1969). The infants were filmed separately each month for the first eight months. The films were then rated by independent groups of raters for each twin pair member. The rated characteristics included: responsiveness to persons, responsiveness to toys, activity, attention span, goal directedness, feafulness, and emotional tone. Fraternal twin differences (within pair) were significantly greater than the within pair differences between identical twins. Bayley (1970) concluded that:

> There is a clear indication that personality or nonintellective behaviors are also genetically determined . . . genetic determiners of mental

> abilities may be based not purely on capacities to carry out varying degrees of abstract thinking, but they may operate through inborn response tendencies which are manifested more generally as behaviors which in themselves are not classed as "intelligence" [p. 1187].

While not all would agree that response tendencies are "inborn" there does seem to be some agreement that patterns of behavior which are non-intellective contributors to intelligence (Wechsler, 1943) are very likely related to some kind of internally directed motivation to succeed.

While Bayley considers the non-intellective factors to have genetic origins, Yarrow, Rubenstein, Pedersen, and Jankowski (1972) have studied the external contributions of the animate and inanimate environment to infant motivation. Infant development was measured by subsets or clusters of items from the Bayley Scales of Mental and Motor Development while aspects of the environment and maternal behaviors were rated by observers. The infants studied were 5 to 6 months old. Positive relationships were reported between social stimulation variables (maternal responsiveness) and infant behaviors such as goal directed behavior, social responsiveness, language, object permanence, and gross and fine motor development. Rated dimensions of inanimate stimulation in the infant's environment were related to all cognitively oriented behaviors but not to the infant's social responsiveness. The infant measures were described as "cognitive-motivational functions [p. 216]" and, in the study, clusters of Bayley items were used to operationally define "motivation":

> Motivation, as we have used it, is not an abstract intervening variable. It refers to clearly specified behaviors, such as reaching persistently for objects, attempting to have an effect on and elicit responses from objects, showing preferential attention to and manipulation of novel objects. These behaviors might be considered expressions of the infant's motivation to assimilate, to learn about, and to master the environment. They may be viewed as an early expression of a competence or an effectance motive (White, 1959) [Yarrow, et al, 1972, p. 217].

Birns and Golden (1972) have also explored the possibility that "there may be continuity in terms of certain personality traits which are related to both pre-verbal and verbal intelligence [p. 53]," and that these traits may provide the "missing link" when used in combination with developmental measures to increase prediction between infant intelligence and later I.Q. A cross sectional and longitudinal sample of 89 black children from lower to middle-class families were tested at 12, 18, and 24 months with the Cattell Scale (Cattell, 1940) and rated at the end of the examination by the examiner on seven personality measures. The Stanford Binet (form L-M) (Terman & Merrill, 1960) was administered when the children were 3 years old. Correlations between personality measures at 18 and 24 months and the Cattell administered at 24 months and the Binet administered at 3 years, indicated that "pleasure at task" measured at 18 and 24 months correlated with the Stanford Binet I.Q. at 3 years. "Attention-persistence" and "cooperation" rated at 24 months also correlated with I.Q. at 3 years when the 2 year I.Q. score was partialled out. Cattell I.Q. scores at 18 months did not correlate with 3 year Binet I.Q. scores. Birns and Golden (1972) suggested that the following research questions are raised by their findings:

> (a) Is pleasure in problem-solving a relatively stable characteristic or trait of children on different tasks and over time? (b) How early can it be detected? (c) Is it an intrinsic temperamental trait in children? (d) To what extent is pleasure in problem-solving modifiable by experience, and are there critical periods when the behavior is

> most susceptive to environmental influences?
>
> (e) What kinds of maternal behaviors foster or inhibit pleasure in problem solving [Birns & Golden, 1972, p. 58]?

The first two questions could be answered by using a longitudinal approach to the study of personality variables during early infancy. Answers to the final two questions could be dealt with by assessing the interactions of personality trait development over time in relation to some characteristics of caretakers in the infant's environment.

> It is likely that the infant's orientation to objects and to people very early becomes part of a feedback system with the environment. His smiling, vocalizing, and reaching out to people; his visually attending to and manipulating objects tend to be self-reinforcing and thus, to some extent, self-perpetuating. These behaviors become part of a system of reciprocal interactions which may characterize a given infant's transactions with the environment over a long period of time. This orientation to the world may be a more consistent and more significant characteristic of the young infant than any specific cognitive ability [Yarrow, et al., 1972, p. 217].

Measurement of the infant's social orientation and his orientation to tasks is one way of determining the reciprocal system of interactions from the infant's side of the transaction. Another way of measuring the feedback system is to look at maternal behaviors in relation to the infant. These behaviors will be considered in the following section.

Maternal Latency Measures

In order to come to some understanding of "maternal behaviors that foster or inhibit pleasure in problem solving [Birns & Golden, 1972]," maternal behaviors in relation to the infant must be evaluated. Maternal behaviors contribute a large proportion of the environmental stimulation and response from which the infant will learn to behave intelligently. The contribution of the environment to competence has been stated by Bloom (1964) in terms of opportunities provided within the environment for attacking and solving problems:

> An environment which restricts these opportunities and which even discourages the individual from attempting to attack and solve problems on his own is likely to retard intellectual development, whereas an environment which encourages problem solving and clear thinking is likely to facilitate the development of intelligence [p. 77].

One of the first problems that the infant must solve is to develop some type of communicative linkage into the environment which results in reciprocal actions from the caretaker (Rheingold, Gewirtz, & Ross, 1959; Brackbill, 1967):

> There either is an innate predisposition to expect reciprocation of some kind to these specific gestures or there is a very quickly acquired expectation of reciprocation in social communication [Bruner, 1968, p. 56].

The problem for the researcher is "how to get from beginnings in the infant organism to the person participating competently in communicative interaction within the framework of a social system [Smith, 1969, p. 214]." This problem is basic to the study of competence. In order to better understand how infants develop relationships which become reciprocal, the child-caretaker relationship or interaction has been the focus of recent research. Stechler and Carpenter (1967) have characterized as alloplastic the mode used by the infant in learning to exert control over his environment via social interaction with his caretaker. The development of this mode may be based on contingent interaction with the mother (Lewis, et al., 1969), or on interactions where infant-caretaker behaviors are mutually reinforcing (Bell, 1971; Brazelton, Koslowski, & Main, 1974; Stern, 1974).

Lewis, et al., (1969) have stated the relationship between contingency and the establishment of motivation or an attitude of "generalized expectancy" and its long term effect on infant competency. They have found that three month old infants showed more response decrement to visual stimulation when the infants had received more contingent stimulation from the mother, and response decrement was even more highly related to latency of the maternal response, i.e., the shorter the maternal response latency the greater the infant response decrement.

To assess the extent to which 5 to 6 month old infants were able to influence their environment, Yarrow, et al., (1972) measured latency of maternal contingent responses to distress and frequency of contingent maternal responses to infant vocalizations. The latency measure was correlated positively with the infant's mental and motor development as measured by the Bayley Scales and also with a cluster of items representing goal oriented behaviors. The frequency measure (maternal contingent response to vocalizations) correlated with only two subscale measures: manipulating novel materials and vocalizing to a bell. The findings relative to the relationship between maternal latency to distress and infant developmental measures supported the findings of Ainsworth (1967) and Lewis and Goldberg (1969) that suggest that:

> . . . early intervention in distress states may have a general facilitating effect, either by freeing the infant to respond to external stimuli or by making him more aware of a contingent relationship with the caretaker [Yarrow, et al., 1972, p. 212].

Bayley and Schaefer (1964) correlated rated behaviors of mothers (noted by the examiner at the time the children were given developmental examinations) (Bayley, 1970) with mental development of the child as measured by the Bayley Scales during the first year. Maternal behaviors were roughly classed into groups of warm, understanding, and loving, as opposed to punitive and harsh; autonomy granting as opposed to controlling and intrusive. Boys' scores were negatively related to expressed maternal affection during the first year while the relationship was reversed for girls. Both boys' and girls' developmental scores were positively related to "controlling, achievement-demanding maternal behaviors [Bayley, 1970, p. 1192]." Bayley concluded that:

> there are clear indications that mental abilities of males are more strongly related than the females, both positively and negatively, to emotional aspects of their environment. There are also

> indications that for the boys, early experiences are likely to have long-lasting effects, even though the nature of these effects may not at first be evident [p. 1201].

In a longitudinal study of 36 infants studied from 9 to 18 months, Clarke-Stewart (1973), factor analyzed ratings of observed maternal behaviors and measures of infant competence. The maternal factor scores found to predict infant competence were those labeled "optimal maternal care" and "maternal intellectuality." The single maternal behavior that was most highly related to infant competence was verbal stimulation, and infant language ability was specifically related to maternal responsiveness to vocalization. Amount of visual contact between mother and child was related to infant social behaviors. One of the infant competence measures was the Bayley Scales of Infant Development (Bayley, 1969). Clark-Stewart found that this measure of competency was most highly related to maternal social and nonphysical stimulation, i.e., looking and talking, and also to observer ratings of maternal responsiveness to infant social behaviors. The maternal responsiveness measure includes rated frequency, latency, and selectivity of response to infant behaviors. Maternal responsiveness was also related to other measures of infant competence such as speed of information processing, schema development, and observer ratings of language and social and emotional competence in the infant. Clarke-Stewart suggests that these findings confirm the "expectance of control" notion (Ainsworth, et al., 1971; Lewis & Goldberg, 1969; Yarrow, et al., 1971). Although this notion has been partially developed from studies measuring maternal responsiveness to distress (Ainsworth, et al., 1971; Bell, 1971; Moss, 1967), Clarke-Stewart found that during the second year of life "responsiveness to social behavior may be a more valuable maternal quality than responsiveness to distress [p. 71]." She further suggested that "maternal responsiveness to the child's social signals was enhancing to the child's later intellectual and social performance [p. 94]."

Elardo, Bradley, and Caldwell (1975) used the Inventory of Home Stimulation (Caldwell, Heider, & Kaplan, 1966) to predict later mental test performance for 77 normal infants studied from 6 months to 3 years. Mental test performance was measured at 6 and 12 months with the Bayley Scales, and the Stanford Binet was administered to the children at 3 years. The purpose of the study was to assess the effects of home environment variables which included maternal characteristics such as emotional and verbal responsiveness, involvement with the child, and avoidance of restriction and punishment, on mental development. Although the relationship between home environmental ratings and 6 month infant mental scale performance was low, the maternal variables measured at 6 months were more strongly related to mental development at 12 and 36 months. The findings suggest that ratings of environmental factors may be measures of:

> a complex of environmental forces which are perhaps prerequisites to later performance on cognitive tasks, and is measuring those forces at a time in the infant's life prior to the period in which such developmental forces have affected the infant's measured development [p. 75].

Clearly, maternal responsiveness to the infant's behaviors has an effect on cognitive growth and the development of competence. Measures of latency of maternal response rather than frequency of behavior appear to be better predictors of measurable effect on the infant (Yarrow, et al., 1972; Lewis & Goldberg, 1969). Response to social behavior (Clarke-Stewart, 1973; Yarrow, et al., 1972; Elardo, et al, 1975) and response to distress (Ainsworth, 1967; Lewis & Goldberg, 1969; Bell, 1971; Moss, 1967) appear to be variables that are useful to predict infant competence across time periods.

Conclusion

Several variables have been discussed that may contribute to emerging competence in the young infant. These particular variables represent a progression from organismic to environmental influences on the young infant. Since intelligence or competence have been theoretically defined as the result of a transactional process between the organism and his/her environment, an attempt was made to choose characteristics of infants and their environment which may form a system that enables the infant to have impact upon his environment. A variable relevant to the infant's physical status at birth, a variable related to emerging and possibly maturationally determined visual information processing, infant personality characteristics, and maternal response variables have been described and their relationship to other measures of competency were discussed. Each of these variables is found to indicate, in some measure, development within the infant of systems for adaptation, coping, and exerting control over the environment.

Purpose

The purpose of this study is to formulate a model of early infant competence from variables representing a transactional perspective of developing competence in early infancy. The variables examined in this study were chosen to reflect a progression from initial organismic status of the neonate to more distal measures of maternal responsiveness within the caretaking environment. The variables for study were also selected in nearly equal number to reflect the organism-environmental transaction between initial levels of physical and visual perceptual development, infant personality characteristics that indicate developing social and task orientation, and maternal measures that could be construed as measures of contingent environmental response to infant behaviors. These combined measures are expected to be useful indicators of a system of organism-environment transactions which will be validated by relating them to an independent measure of developing competence.

After the model of early infant competence is validated against an external criterion measure of competence, it will be tested to determine if the model is useful in predicting emerging competence across time as indexed by the external criterion measure in early infancy. The model's ability to predict competence will be compared to the predictive usefulness of the external criterion measure across time.

In order to validate the model of early infant competence, an independent criterion measure of infant competence in mental and motor areas, the Bayley Scales of Infant Development was selected. These scales have been used as measures of infant competence, e.g. Clarke-Stewart (1973), Yarrow, et al., (1971), and were chosen because they present to the infant a variety of age appropriate tasks in a novel setting that measure a broad range of behaviors regarding the infant's ability to adapt to environmental demands. Clarke-Stewart (1973) has described these scales as "measuring a comprehensive range of specific competencies as they are affected by the child's motivation to perform in a novel situation [p. 71]."

Hypotheses

Hypothesis 1. A model of early infant competence can be developed from measures of organismic and environmental variables which will account for a statistically significant proportion of the variance in independent criterion measures of infant competence at 2½ and 6 months.

Hypothesis 2. Each of these infant and environmental characteristics will contribute to the transactional system through which the infant develops competence.

Hypothesis 3. These transactional measures will describe the development of competence from one age to another. This hypothesis is based on the assumption that outcome performance is based on the past interaction of the organism and his/her environment.

Hypothesis 4. Clusters of variables relative to the infant's physical-maturational status, his/her personality characteristics, and maternal behaviors, will differ for males and females in their relationship to infant competence.

Method

Subjects

The subjects in the sample were participants in a two year longitudinal study carried out at the Peabody Infant Laboratory. In order to maximize the changes for obtaining complete data on the desired sample size, N=48, a predominantly middle-class group was selected to participate in the study. Names of all families to be contacted were selected initially from birth records at the Tennessee State Department of Public Health according to the following criteria: all infants were firstborn, full-term singletons with birth weights between 5.5 and 9.5 pounds and were free of significant health complications as indicated on the birth record; parents of these infants were married, with each parent over 20 years of age and at least a high school graduate. All of the information contributing to these criteria is given on each birth record in Tennessee. As part of this research was to be conducted in the home, an additional selection factor involved geographic location. Families living at a distance greater than 20 miles from that part of central Nashville, Tennessee were excluded. In addition, as the initial contact with all parents was by telephone, families who met all other criteria but were without telephone service or who had unlisted phone numbers were not accessible for recruitment.

Parents of infants who met the above criteria were contacted in random order by telephone and the purposes and requirements of the study were introduced by a female research assistant. Before further information was given, it was determined that the mother was the primary week-day caretaker and that the family would be in the city for the next year. For parents who were interested in possible participation, a letter explaining the details of the study and what was required for participation was sent with the understanding that a second phone call a week later would be made to see if the family was still interested. At the time of the second phone call, if the family was interested in participating in the study, an initial appointment to conduct the observational session was made. Table 1 describes the number of potentially qualifying families selected and those which were located by telephone listing, contacted, sent the letter, and agreed or refused to participate. Since the data had to be collected as the infants were born, it was not possible to randomly select the sample from the population as a whole. However, as much as possible, the families who were included were randomly selected from the ones who were sent letters. The birth rate did not allow completely random selection at any one time. Families were contacted initially when the infant was 7 weeks old in order to allow ample time to recruit the sample for any one week and still see the mother and infant when the infant

Table 1

Potential Sample of Families Meeting Selection Criteria

From Birth Records 12/24/73 - 4/18-74

	Total Frequency	%	High Ed.* Frequency	%	Low Ed. Frequency	%
Potential N	213		148		65	
No Phone	44	21	27	18	17	26
Never contacted	22	10	19	13	3	5
Contacted by phone	147	69	102	69	45	69
Refused initial contact	44	21	20	14	24	37
Letter sent	103	43	82	55	21	32
Refused after letter	49	23	37	25	12	18
Included in study	54	25	45	30	9	14

*Both parents education = 14 years

was 10-11 weeks of age. Table 2 includes the characteristics of participating infants and parents, for infant's age at Phase I, birth weight of infant, weight at time of Phase I, mother's age and education and father's age and education. As can be seen from the data, there are no apparent differences between males and females in the study.

The study began with 54 subjects 2½ months of age. Two families (one male and one female subject) moved from the area during the first phase of data collection. Another male infant was seen in our laboratory at 2½ months and, based on our observations of poor weight gain and depressed performance on the

Table 2

Characteristics of Sample

	Males			Females		
	$\bar{X}$	Range	S.D.	$\bar{X}$	Range	S.D.
Infant Age (in days)	75.78	69-84	4.22	75.33	69-84	4.03
Birth Weight	121.6	101-142	11.1	119	95-155	13.23
Mother's Age (years)	26.26	24-32	2.44	25.59	21-31	2.78
Mother's Education	15.41	12-18	1.74	15.19	12-18	1.78
Father's Age (years)	28.44	24-42	4.41	27.81	24-34	3.00
Father's Education	16.26	12-19	1.63	16.11	12-18	1.45

developmental scales, a medical referral was made. The infant was hospitalized for cardiac surgery and subsequently died. Therefore, 51 infants, 26 females, and 25 males were included as subjects in the present study.

Data Analysis

The data were analyzed using multiple linear regression analysis (Bottenberg & Ward, 1963). A full model consisting of the organismic, personality, and environmental variables was formulated and tested against criterion variables. The Bayley Developmental Index and the Bayley Motor Index were used to determine the relationship of the model and its individual predictor variables to the external criteria at 2½ and 6 months. Additional analyses were performed in the same manner to test the full model at 2½ months against the 6 month criteria. Multiple linear regression analysis was used so that the relationship between mental and motor development and the groups of variables indicative of emerging competence could be examined, while simultaneously holding over variables constant. Since competence has many ramifications, such an approach appears to be the most appropriate treatment of the data.

The second level of analysis involved calculating Pearson Project moment correlation coefficients between subsets of variables for all subjects, and separately for males and females. The shift to this type of analysis for sex differences was used rather than applying multiple linear regression analysis to the data for each sex as analyzing half of the total sample data (by sex) would tend to capitalize on change because of the diminished number of subjects in each analysis in relation to the number of variables used in the model (Nunnally, 1967).

Instrumentation

(1) Birth weight: Infant weight was measured in ounces at the time of hospital delivery by attending medical personnel.

(2) Habituation Index: When the infant was judged to be in

a "good" state (quiet, alert) he/she was positioned about twelve inches from a plexiglass rear-projection screen. The 2½ month old infant was placed on its mother's shoulder or in her lap. At 6½ months, infants were seated in a feeding table in front of the screen.

As soon as the infant was comfortable, a slide to orient the infant to the screen was presented. When the infant looked at the slide, it was replaced by the first of two pictures to be used in the session. The slide remained on the screen for the length of time the infant was judged to be looking at the picture by one of two observers. While the infant was judged to be looking, the observer O_1 depressed a silent push-button which activated a pen on an event recorder and also activated a laboratory timer visible only to the observer (O_2). A trial is determined by the length of time the infant looked at the slide. When O_1 judged that the infant was no longer looking at the slide, she removed her finger from the button and the picture went off. At the same time, a flashing Christmas light came on, on one side of the screen, for the length of time the picture was off the screen. At the end of 3 seconds, the picture came on the screen and the flashing light went off. The time between the presentation of the slide and the commencement of looking was automatically recorded on the event recorder and gave a measure of latency of "attention getting." The criterion for habituation was one half the length of looking on two consecutive trials as compared to the average looking time on the first two trials. O_2 calculated this criterion and decided when habituation had occurred. When this had been determined, O_2 changed the slide to test for recovery.

In order to insure that recovery was actually being demonstrated, half the infants received two extra trials with the first slide after reaching criterion, before being shown the new slide. The new slide was shown for two presentations, then the first slide was shown again. The two stimuli used for the 2½ month olds were black and white checkerboards, 144 sq. and 36 sq. They were counterbalanced with sex and whether presented for two extra trials or not.

Dependent variables included number of trials to criterion, amount of attentional decrement, amount of recovery of attention, latency to fixate the slides, and whether the infant showed habituation on re-presentation of the original slide.

Because 6 month old pilot infants did not maintain sufficient attention to the checkerboard stimuli used for the infants at 2½ months, it was decided that facial stimuli would be utilized for infants at 6 months. Color photographs of a girl smiling and frowning were tested and proved to be attractive enough to infants to warrant their maintained attention for up to 30 seconds initially. Pilot testing also indicated that some infants looked for less than 10 seconds and so the initial looking criterion was lowered to mean looking time of 8 seconds taken on two consecutive presentations. The decrement criterion of a 50% reduction in looking time was selected. Infants were held by their mothers during the habituation procedure in order to minimize fussing. In order to provide controls for fatigue, half the infants were tested with the smiling face and half with the frowning face with the other stimulus used to test for recovery of attention. In addition, to insure that failure of recovery is not due to the similarity of the stimuli, an upside-down monochrome face was presented at the end of the series for two presentations. In order to provide positive evidence of true habituation, half of the subjects were shown the initial stimulus for two extra trials following their reaching decrement criterion before being presented the second stimulus.

The index for habituation included a measure of the magnitude of response decrement in relation to number of trials to criterion. The formula for the index is proportion of $\bar{x}$ initial looking time - (minus) proportion $\bar{x}$

decrement looking time ÷ trials to criterion. This formula controls for inter-subject variability in base response rate and emphasizes the proportionate change in each infant's response. The formula gives advantage to infants who process or encode information in the fewest possible trials. (3) Personality measures: The infants were rated at 2½ and 6 months on all items of the Infant Behavioral Record (Bayley, 1969). The ratings were completed by the same examiner who administered the Bayley Developmental Scales immediately following the developmental evaluation and prior to scoring of the developmental scales to reduce the possibility of "halo" effect. These scales were administered in the same laboratory setting for all subjects. The infants were seated on their mother's laps for the evaluation. The rating scales are not part of the standardized group of items that make up the Bayley Scales of Infant Development.

Selected items were chosen from the Behavioral Rating Scale which have face validity as measurements of the infant's "Social Orientation" and "Task Orientation" as observed in the examination setting.

a. Social Orientation: This scale is a compilation of rated items which involve ratings of the infant's responsiveness to persons, responsiveness to the examiner, responsiveness to the mother, and cooperativeness with the examiner based on interpersonal reactions (Bayley, 1969). The scale is included in appendix A.

(Internal consistency of the scales is relatively high [Alpha = .84 at both 2½ and 6 months].)

b. Task Orientation: Items selected from the Infant Behavioral Record for this scale assess the infant's level of responsiveness and involvement with the materials and tasks presented during the developmental examination. The rated items include: responsiveness to objects, toys, or test materials; persistence in goal-directed effort; tendency to persist in attending to any one object, person, or activity aside from attaining a goal (attention span); and behavior constancy in adequacy of response to demands of the tests (endurance). This scale may have also been called a measure of the infant's pleasure at task, and is contained in appendix B.

(The internal consistency of this scale for the two time periods is relatively high [Alpha = .87 at 2½ months and .86 at 6 months].)

(4) Maternal measures:

a. Observational. A total of 90 minutes of observational data was collected when the infants were 2½ and 6 months old. A single observer collected the data in the child's home. Following initial adaptation of the family to the observer's presence and procedure, mother-infant interaction were recorded continuously on a Datamyte Recorder. This recorder allowed the observer to record continuously any events pre-coded into numerical codes on a cassette audio tape recorder. The data was transferred automatically to computer teletype and magnetic tape for data reduction and processing. The recorder allowed the observer to maintain attention constantly on the events being observed while recording events. In addition, the time of each event was entered automatically by an internal clock, thus, not only order or events, but also latencies and durations were recorded. For a complete description of the data collection and reduction see Strain (1975). From these data, two measures of maternal latency were extracted as they index a dimension of maternal contingent responsiveness to infant behavior. The two measures are: maternal latency in response to infant's distress vocalization and maternal latency in response to infant's social (vocal) behaviors.

The latency of maternal responses were recorded in 10 second time segments following the onset of infant behavior. Maternal behaviors were coded that could be categorized as looking at, vocalizing to, smiling at, or touching and/or playing with the infant. Inter-observer reliabilities for the duration of maternal behaviors are contained in Table 3.

Table 3

Inter-observer Reliabilities on Home Observations of Maternal Child Behaviors

Maternal Categories	2½ Month Duration	6 Month Duration
Looks at infant		
n	6	8
r	.870	.904
Vocs. to infant		
n	6	8
r	.820	.9425
Smiles at infant		
n	6	7
r	.813	.8828
Touch-play		
n	2	4
r	.745	.917

n = number of subjects

Initial data collection for reliability purposes was planned to continue until acceptable levels of agreement for each behavioral category on six dyads, three with male infants and three with female infants, were reached. Inter-observer agreement checks were made again at the mid-point and near the end of data collection on the 24 dyads in the pilot study and throughout the data collection in Phase I. In-process observation visits, were made by both observers who collected data on the entire session for reliability purposes. A total of 20-30 minutes from each observer's record contributed to the reliability check for each observation session from the initial, middle, and final portions of the 90 minute session.

Since dependent variables in the form of overall duration of behaviors and antecedent-consequent relationships within 10-second intervals were used in data analyses, inter-observer agreement was established on the reliability data for both types of scores. To assess the reliability on duration of behavior categories, the records were divided into consecutive 1-minute segments. The duration of each category of maternal and infant behavior was summed per minute. This process was carried out on each observer's record. Pearson product-moment correlation coefficients were calculated between the two observers for each category, using the duration of the category, in seconds, for each 1-minute interval (see Table 3).

b. Rated. Following the 90 minute observational period the observer made ratings of various environmental parameters. Two latency ratings were made: maternal latency to distress (see appendix C) and responsiveness to infant social behaviors (see appendix D). These measures were collapsed into one measure: Maternal responsiveness to infant behaviors. This rated measure was included in that it may reflect more the qualitative differences in maternal behavior than the above measures of latency of response measured in seconds.

(5) Bayley Scales of Infant Development: The Bayley Scales of Infant Development were individually administered when the infants in the sample were 2½ and 6 months old. The scales were administered in the infant laboratory by the same white female examiner for all subjects. The Bayley Scales are one of the most carefully constructed and standardized instruments of overall infant developmental status and have excellent psychometric characteristics. Use of the Bayley Mental and Motor Scales provided data of potential

value for comparisons with the standardly-referenced infant literature. The Bayley Scales of Infant Development were designed to provide an evaluation of a child's developmental status during the first two and one-half years of life. There are three parts: the mental scale, designed to assess sensory-perceptual acuities, discriminations, and the ability to respond to these; the motor scale, designed to provide a measure of the degree of control of the body, coordination of the large muscles and finer manipulatory skills of the hands and fingers; and the infant behavior record, designed to assess the child's social and objective orientations toward his environment.

The Mental Developmental Index (DI) and Psychomotor Developmental Index (MI) are derived from administration of the Mental and Motor Scales respectively (The Infant Behavior Record yields qualitative observations only). Both the Mental Index and the Motor Index are normalized standard scores, having the same numerical characteristics as the commonly-used "deviation IQ."

Results

Hypothesis I: A model of infant competence consisting of infant variables that include: birth weight (Bwt), habituation index (HI), social orientation (SO) and task orientation (TO) and maternal variables that include: rated maternal sensitivity to infant social and distress signals (MR), observed latency to respond to infant distress vocalizations (OMLD), and observed maternal latency to respond to infant non-distress vocalizations (OMLV), accounts for a statistically significant proportion of the variance in external criterion measures of infant competence, Bayley Developmental Index (DI) and Bayley Motor Index (MI) when the infants are 2½ and 6 months old.

The first level of multiple linear regression analysis was performed on infant and maternal predictor variables at 2½ and 6 months to predict infant scores on the Bayley Developmental Index (mental development) and the Bayley Motor Index (motor development). The results of these analyses are reported in Table 4 for the criterion variables MI and DI at the two ages. This level of analysis indicated that, indeed, a significant proportion of the variance in both mental and motor development can be accounted for by the

Table 4

All Infant and Maternal Variables Predicting MI and DI against Zero

Criterion Variable	Age (months)	R	R^2	F	P
DI	2½	.75	.56	7.733	.01
MI	2½	.77	.60	7.94	.01
DI	6	.64	.42	4.364	.01
MI	6	.52	.27	2.22	.05

df = 7, 43

combination of infant and maternal variables at both ages. At 2½ months over 50% of the variance was accounted for by the group of variables predicting DI and MI. At 6 months the percentage of variance accounted for declined to 42% for DI and 27% for MI. Hypothesis 1 was confirmed.

Hypothesis II: Each of the predictor variables: birth weight, habituation index, social orientation, task orientation, rated maternal responsiveness to infant social and distress signals, observed maternal latency to respond to infant distress vocalizations, and observed maternal latency to respond to infant non-distress vocalizations; will contribute significantly to the total amount of variance accounted for in the model which contains all of these variables to predict infant mental and motor competency at 2½ and 6 months.

Multiple linear regression was performed testing each variable against the full model[1] which consisted of all the variables used to predict mental and motor development separately at 2½ and 6 months. Table 5 contains the results of these analyses for 2½ months.

Table 5

Individual Predictor Variables Tested Against the Full Model at 2½ Months

Predictor Variable	Criterion Variable					
	DI			MI		
	R	R^2	F ratio	R	R^2	F ratio
Bwt	.28*	.077	7.876**	.45**	.20	7.028**
HI	.02	.00	9.123**	.17	.03	10.08**
SO	.406**	.165	6.434**	.38*	.15	7.995**
TO	.69**	.48	1.358	.54**	.29	5.462**
MR	.045	.00	9.098**	.05	.00	10.548*
OMLD	.18	.03	8.621**	.372**	.14	8.127*
OMLV	.115	.01	8.913**	.077	.00	10.481*

* = p .05; ** = p .01; df = 6, 43

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[1] The probability level attached to the F test of the single variable against the full model indicates that when a single variable contributes a large enough proportion of the variance to prediction of MI or DI so that the full model does not differ significantly from the single variable model, the level of probability will be >.05. The probability levels attached to the R for each variable in relation to the full model are based on Pearson Project Moment Correlations (df = n-2 subjects).

For the DI criterion, only one variable, task orientation (TO) used as a restricted model tested against the full model at 2½ months, did not yield significant differences between the models. However, there are no single variables used as restricted models in the MI models when tested against the full model that do not yield significant differences between the models.

Several variables correlate significantly with the full models for both DI and MI. Birth weight (Bwt), social orientation (SO), and task orientation (TO), correlate significantly with the full model used to predict DI. Significant correlates of the model used to predict MI are: birth weight (Bwt), social orientation (SO), task orientation (TO), and observed maternal latency to respond to infant's distress vocalizations (OMLD). Task orientation contributes the largest proportion of the variance to both DI and MI since only variable does not contribute significantly to the prediction of MI and DI therefore, Hypothesis II was not confirmed at 2½ months.

The results of testing Hypothesis II at 6 months are contained in Table 6. The same multiple linear regression models used at 2½ months were used to test each variable separately against the full model for the 6 month infant and maternal predictors.

Table 6

Individual Predictor Variables Tested Against the Full Model at 6 Months

Predictor Variable	DI			MI		
	R	R^2	F ratio	R	R^2	F ratio
Bwt	.18	.03	4.674**	.02	.00	2.59*
HI	.32*	.10	3.85**	.32	.10	1.619
SO	.47*	.22	2.37*	.25	.07	1.96
TO	.48**	.23	2.26	.35*	.12	1.42
MR	.20	.04	4.597**	-.27*	.07	1.869
OMLD	.18	.03	4.698**	.20	.04	2.219
LMLV	.19	.04	4.638**	.16	.03	2.349*

* p = .01
** p = .05

df = 6, 43

In the full DI model which accounts for 42% of the variance in mental development at 6 months only one variable, task orientation (TO) used as a restricted model does not differ significantly from the full model. Several variables produce significant F tests for the MI models. However, it should be noted that the full model accounts for only 27% of the variance in motor development at 6 months, and, therefore, while each of these variables may not differ from the amount of variance accounted for by the full model, it is obvious that other variables beyond the scope of this study may account for the major proportion of the variance in motor development at 6 months. The variables tested singly that did not differ significantly from the full model in amount of variance accounted for are: habituation index (HI), social orientation (SO), task orientation (TO), rated maternal sensitivity to infant social or distress signals (MR), and observed maternal latency to infant distress vocalizations (OMLD).

Several variables correlate significantly with the full DI model (see Table 5). The following variables correlate positively with the DI model: HI, SO, and TO. HI, and TO are correlated positively with the MI model while MR is correlated negatively with the MI model.

The results of testing Hypothesis II at 6 months indicated that the hypothesis was only partially confirmed as each variable does not contribute significantly to the prediction of mental or motor development, and the overall amount of variance accounted for the full models, although, statistically significant, is less than half of the total variance for both mental and motor development.

To obtain a somewhat finer grade analysis of the contribution of subsets of variables to full models containing subsets of predictor variables, a "stepped down"[2] multiple linear regression analysis was performed on the infant and maternal variables used to predict DI and MI at 2½ and 6 6 months. In this analysis, while variables are cumulatively extracted from the restricted models, each variable that has been previously tested is removed from the succeeding full model. In this manner, the variance accounted for by the extracted and tested variable is eliminated from succeeding full models so that significant differences between full and restricted models in preceding analyses do not influence succeeding F tests between restricted and full models. Unlike a step-wise regression routine, this procedure facilitates a more controlled approach to testing the relative usefulness of each predictor variable. The variables were extracted in an order which included infant variables and then maternal variables. The order for extraction of variables was: Bwt, HI, SO, TO, MR, OMLD, and OMLV, so that the final test between restricted and full models involves OMLV against OMLD and OMLV. The results of these analyses at 2½ months are contained in Table 7 for the DI and MI criterion variables.

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[2] This analysis involves extracting a single variable and testing the remaining restricted model against the full model to determine if the amount of variance accounted for by the extracted variable produces significantly different restricted and full models. After the first variable is extracted and the remaining restricted model is tested against the full model, another variable is added to the one initially extracted and the remaining variables constitute the new restricted model. The full model against which this restricted model is tested excludes the variance accounted for by the variable that was excluded in the first step.

Table 7

Stepped Down sets of Predictor Variables Tested Against Decreasing Full Models at 2/12 Months

	DI			MI	
Full model	Rest. Model	F	df	F	df
Bwt, HI, SO, TO, MR, OMLD, OMLV	HI, SO, TO, MR, OMLD OMLV	3.985*	1,43	18.810**	1,43
HI, SO, TO, MR. OMLD, OMLV	SO, TO,.MR, OMLD, OMLV	.048	1,44	.000	1,44
SO, TO, MR, OMLD, OMLV	TO, MR, OMLD, OMLV	1.306	1,45	.024	1,45
TO, MR, OMLD, OMLV	MR, OMLD, OMLV	41.314**	1,46	19.560**	1,46
MR, OMLD, OMLV	OMLD, OMLV	.015	1,47	.701	1,47
OMLD, OMLV	OMLV	2.052	1,48	2.052**	1,48

* .05 level of significance
** .01 level of significance

df = degrees of freedom

At 2½ months the extraction of Bwt and TO creates models that differ significantly from the full models for DI and MI. The extraction of the maternal variable, OMLD, from the MI models created a model that differed significantly from the OMLD-OMLV full model. This analysis corroborates the correlations found when each variable was tested against the full model (see Table 5) with one exception: SO, although significantly correlated with the full model that included SO, when extracted and tested against a decreasing full model, fails to produce a model that is significantly different from the full model. The results of a stepped down analysis performed on the 6 month data using the same procedure that was used for the 2½ month data are contained in Table 8.

The results of this analysis indicate that the extraction of SO and TO account for significant differences between the full DI models which included them and the restricted model from which they had been extracted. Only the extraction of TO created a significant difference between the restricted model from which it had been extracted and the full model for MI. Although the combination of all of the predictor variables accounts for only 27% of the variance in MI at 6 months the major portion of variance accounted for in the full model is contributed by TO.

Table 8

Stepped Down Sets of Predictor Variables Tested Against Decreasing Full Models at 6 Months

Full Model	DI Rest. Model	F	df	MI F	df
Bwt, HI, SO TO, MR, OMLD, OMLV	HI, SO, TO, MR, OMLD OMLV	2.021	1,43	.003	1,43
HI, SO, TO MR. OMLD, OMLV	SO, TO, MR, OMLD, OMLV	1.893	1,44	1.995	1,44
SO, TO, MR, OMLD, OMLV	TO, MR, OMLD, OMLV	4.834*	1,45	.749	1,45
TO, MR. OMLD, OMLV	MR, OMLD, OMLV	10.834**	1,46	4.097*	1,46
MR, OMLD, OMLV	OMLD, OMLV	1.674	1,47	3.351	1,47
OMLD, OMLV	OMLV	1.884	1,48	2.166	1,48

* .05 level of significance
** .01 level of significance

df = degrees of freedom

Summary of regression analysis at 2½ months

While Bwt, SO AND TO are significant correlates of the full DI model (containing all predictor variables), TO alone is the most useful predictor of DI, while Bwt is the next most useful predictor of DI. For the MI models, TO is also the most useful predictor followed by Bwt, and OMLD. The relationship between MI and OMLD indicates that long maternal latencies to respond to infant distress signals is related to high infant motor development.

Summary of regression analysis at 6 months

While the set of predictor variables account for less than half of the variance in DI and MI at 6 months, TO continues to be the best single predictor of both DI and MI. SO contributes 22% of the variance to DI while HI contributes 10% of the variance to both the DI and MI models. A maternal variable, MR, and SO each contribute 7% of the variance to the MI model. The MR variable is negatively correlated with MI indicating the relationship between low rated maternal responsiveness and high infant motor development.

The findings at 6 months represent findings that are analogous to the 2½ month findings, however, HI replaces Bwt in predicting MI at 6 months and low rated maternal responsiveness (MR) at 6 months replaced another long latency maternal measure OMLD in predicting MI.

Because OMLD is a significant predictor variable of MI at 2½ months, multiple linear regression was performed on infant and maternal variables to predict OMLD. The infant predictor variables included in this analysis were the Bwt, HI, DI, and MI. Maternal variables were also used to predict maternal response to distress included: OMLV, MRS, and MRD. This combination of variables was selected to determine if

OMLD could be predicted from infant or maternal characteristics, for example does the mother's own behavior in response to other infant behaviors predict her response to distress, or do infant characteristics serve as predictors of this maternal behavior? The results of this analysis indicate that a significant proportion of the variance in OMLD can be accounted for by using these predictor variables (R = .59, R^2 - .35, F = 3.327, df = 7, 43, p = .01) and are contained in Table 9. Each variable was extracted successively, beginning with infant variables, and the remaining predictor variables formed the restricted model that was tested against the full model containing all predictor variables.

Table 9

Infant and Maternal Variables Used to Predict Observed Maternal Latency to Infant Distress Behaviors at 2½ Months Tested Against Full Model (Bwt, HI, DI, MI, OMLV, MRD, MRS)

Restricted Model	F	df
HI, DI, MI, OMLV, MR, MRS	6.988**	1,43
DI, MI, OMLV, MRS, MRD	3.599*	2,43
MI, OMLV, MRS, MRD	2.424	3,43
OMLV, MRS, MRD	3.767**	4,43
MRS, OMLV	3.495**	5,43
MRS	3.201**	6,43

* .05 level of significance
** .01 level of significance

df = degrees of freedom

The subset of variables that did not differ significantly from the full model contained the infant's MI in combination with all other maternal variables. Further extraction of maternal variables from the restricted model produces models that differ significantly from the full model indicating that the infant's MI is the best single predictor of OMLD. In this analysis, MI and OMLD are inversely related (r = .372, p. 01) which indicates that long maternal latency to infant distress signals and high motor competence are significantly related. The second most significant predictor of OMLD is the infant's birth weight. The model which includes Bwt and all other predictor variables accounts for 59% of the variance in OMLD, while the model that excludes Bwt but includes all other predictor variables accounts for 50% of the variance in OMLD. The correlation between Bwt and OMLD is not significant (r = .086), however, Bwt correlates with the significant predictor variable MI (r = .488, p = .01).

Hypothesis III: Variables that represent the infant's status at birth (Bwt), a measure of the infant's visual information processing (HI), and infant personality characteristics (SO and TO), in addition to maternal latencies to infant distress (OMLD) and vocal behavior (OMLV), and rated maternal sensitivity to respond to infant social and distress behaviors (MR), measured at 2½ months will predict a statistically significant proportion of the variance of DI and MI measured at 6 months.

Multiple linear regression analysis was performed on the 2½ month predictor variables to predict the DI and MI criterion variables measured at 6 months. The results of this analysis are contained in Table 10. The proportion of the variance accounted for by the 2½ month variables for DI and MI at 6 months was not statistically significant (p .05). Less than 20% of the variance was accounted for in the DI model (R^2 = .1997, p .05) and in the MI model (R^2 = .1673, p .05).

Table 10

2½ Month Variables to Predict DI and MI at 6 Months

Criterion Variable	R	R^2	F	df	p
6 month DI	.4468	.1997	1.532	7,43	NS
6 month MI	.4091	.1673	1.235	7,43	NS

Although the selected 2½ months variables failed to predict a significant proportion of the variance in DI and MI at 6 months, possibly the infant's own DI and MI at 2½ months are significantly related to DI and MI at 6 months. Pearson Product Moment Correlations were calculated. The results of these analyses are contained in Table 11. The upper right and lower left quadrants contain across age correlations, while the upper left and lower right quadrants contain within age DI/MI correlations. Only statistically significant correlations are reported.

Table 11

Significant DI/MI Correlations for All Subjects
at 2½ and 6 Months

	2½ Months		6 Months	
	DI	MI	DI	MI
DI (1)	--	.597**		
MI (1)	.597**	--	.379**	.326*
DI (2)		.378**	--	.702**
MI (2)		.326*	.702**	--

* .05 level of significance
** .01 level of significance
df = 49

MI at 2½ months is significantly correlated with both DI and MI at 6 months indicating that the use of MI alone at 2½ months will predict DI and MI at 6 months as well as the combination of 2½ month predictor variables, therefore, Hypothesis III was not confirmed. The relationship between high motor competence at 2½ months and high mental and motor competence at 6 months demonstrates a pattern of growth where motor competence serves as the basis not only for further motor development but also for mental development or competence.

Patterns of correlations by sex across age:

To explore the possibility that sex differences may be present in patterns of correlations across age, Pearson Product Moment Correlations were calculated for all subjects and then separately for males and females. The following sets of tables will report only statistically significant correlations ($p < .05$). The tables are arranged so that within age correlations are reported for 2½ months in the upper left quadrant and for 6 months in the lower right quadrant. Across age correlations from 2½ month variables to 6 month variables are reported in the upper right quadrant, while correlations between 6 month variables and 2½ month variables are reported in the lower left quadrant. The format for the tables is shown in Figure 1. The 2½ month variable names are followed by (1) while the 6 month variable names are followed by (2). The variable MR used in the regression equations has been separated into its original components: rated maternal latency to respond to infant distress behaviors (MRD), and rated maternal latency to respond to infant social behaviors (MRS). Comparisons between correlates of

Variables	2½ Months	6 Months
2½ month variables (1)	(correlations within the 2½ month period)	(correlates between 2½ and 6 month variables)
6 month variables (2)	(correlations between 6 month and 2½ month variables)	(correlates within the 6 month period)

Figure _. Pattern for Reporting Within and Across Age Correlations.

variables were made by linking variables into subsets of the original predictors. These subsets are arranged into DI/MI correlates, Bwt/HI correlates, personality correlates: SO/TO, and maternal variable intercorrelations. Only maternal variable correlates are reported as it would be redundant to report the correlates of maternal variables as they are reported in the tables that precede them.

Correlates of DI/MI:

The within and across age correlations between DI and MI have been reported in Table 11 for all subjects. These results indicated a significant relationship between MI at 2½ months and DI amd MI at 6 months. Table 12 contains the DI/MI correlations across age for males and Table 13 contains the results of the same analysis for females.

The DI/MI correlations are quite different for males and females. For males there are no significant across age relationships between DI and MI. However, for females nearly

Table 12

Significant DI/MI Correlations for Males at 2½ and 6 Months N = 25

	2½ Months		6 Months	
	DI	MI	DI	MI
DI (1)	--	.618**		
MI (1)	618**	--		
DI (2)			--	.672**
MI (2)			.672**	--

* .05 level of significance
** .01 level of significance

df = 23

Table 13

Significant DI/MI Correlations for Females at 2½ and 6 Months N = 26

	2½ Months		6 Months	
	DI	MI	DI	MI
DI (1)	--	.560**		
MI (1)	.560**	--	.613**	.403*
DI (2)		.613**	--	.714**
MI (2)		.403*	.714**	--

* .05 level of significance
** .01 level of significance

df = 24

40% of the variance in DI at 6 months can be accounted for by MI at 2½ months ($r^2 = .376$), while a more modest proportion of the variance in 6 month MI is accounted for by 2½ month MI ($r^2 = .162$). Therefore, while across age prediction of DI and MI was possible for the females in this sample, there was no significant across age prediction based on DI or MI for males. These findings indicate that at this early age females' motor competence is related to both mental and motor competence over time, and females give evidence of having more stable functioning with regard to these measures. In early infancy some of the poor predictive value of infant tests may be partially attributed to sex differences in rates of stabilization of functioning in combination with the changing nature of competence from motor to mental _and_ motor competence during the first six months of life.

To further explore the possibility of different patterns of relationships by sex over time, correlations were calculated for all of the predictor variables used in this study with DI and MI within and across age for all subjects and then separately for males and females. The format for the tables of correlates of DI/MI is shown in Figure 1. The significant correlations between predictor variables and DI/MI for all subjects are reported in Table 14.

Table 14

Significant DI and MI Correlates for All Subjects at 2½ and 6 Months N = 51

Variable	2½ Months		6 Months	
	DI	MI	DI	MI
Bwt	.277*	.448**		
SO (1)	.407**	.382**		
TO (1)	.691**	.537**		
OMLD (1)		.372**		
HI (2)			.318**	.316**
SO (2)			.471**	
TO (2)		.383**	.481**	.346**
MRS (2)		-.279*		

* .05 level of significance
** .01 level of significance

df = 49

For all subjects, Bwt, SO and TO are correlated with both DI and MI at 2½ months while OMLD is related to MI indicating an association between long maternal latency to respond to infant distress signals and high motor competence. At 6 months the significant correlates of DI and MI are HI and TO while SO is related only to DI. While no 2½ month variables correlate significantly with DI and MI at 6 months, the infant's MI at 2½ months is related to TO at 6 months, and is negatively related to MRS at 6 months (indicating a relationship between long rated maternal latency to respond to infant social behavior and high MI at 6 months).

The correlates for DI and MI for males are contained in Table 15 while those for females are contained in Table 16.

Table 15

Significant DI and MI Correlates for Males
at 2½ and 6 Months N = 25

Variable	2½ Months		6 Months	
	DI	MI	DI	MI
Bwt		.635**	.415*	
SO (1)		.498**		
TO (1)	.756**	.656**		
TO (2)				.442*
OMLV (2)				-.512**

* .05 level of significance
** .01 level of significance
df = 23

Table 16

Significant DI and MI Correlates for Females
at 2½ and 6 Months N = 26

Variable	2½ Months DI	2½ Months MI	6 Months DI	6 Months MI
Bwt	.341*	.346*		
SO (1)	.465*			
TO (1)	.666**	.476*		
MRD (1)				-.388*
OMLD (1)		.471*	.427*	
HI (2)			.390*	
SO (2)			.508**	
TO (2)		.515**	.556**	
MRD (2)		-.462*		-.440*

* .05 level of significance
** .01 level of significance

df = 24

When correlates of DI and MI across age were calculated for males, only TO is significantly related to DI at 2½ months, while Bwt, SO and TO are related to 2½ month MI. At 6 months Bwt is a significant correlate of DI for males, and TO and OMLV are related to MI. The relationship between the maternal variable and MI indicates that a short maternal latency to respond to infant vocalizations is related to high MI at 6 months. Only one variable, Bwt, is related across age to DI for males indicating that high DI at 6 months is related to high birth weight.

The correlates of DI and MI for females across age indicate a different pattern of relationships. While female Bwt is related to DI and MI at 2½ months, it is not significantly related to either at 6 months. Maternal variables are significant correlates of female MI at 2½ months which is not the case for males, and for females, maternal behaviors involving long latencies of response to infant distress signals at 2½ months are related to mental and motor competency at 6 months. The female's motor competence at 2½ months is related to task orientation at 6 months, and is related to long maternal latency to respond to distress at 6 months.

The results for males and females indicate that males are influenced longer by their initial physical status than are females, while female behavior is linked to maternal variables at an age earlier than for males. It would appear that females "overcome" initial physical influences earlier than males, and, therefore, their performance becomes more adaptive to environmental influence at an earlier age. This pattern of relationship between maternal behavior and infant performance seems to emerge at 6 months for males, however, their initial adaptation is again different from females as their motor performance is not related to long latent maternal responses as for females, but rather, to short maternal latency to respond to infant vocal behaviors. Where the high competent female infants appear to thrive in an environment where their distress signals are not responded to immediately, males begin to show evidence at 6 months of a relationship between rapid social reinforcement to vocal behaviors and motor competence. Therefore, the paths to competence appear to diverge for males and females at an early age. The patterns of physical and environmental influences on their behaviors differ in that female motor competence is linked to long maternal latency to distress at 2½ months, and motor competency at 2½ months is related to both mental and motor competence at 6 months. For males there is little relationship between mental or motor competence between 2½ and 6 months, but at 6 months motor competence (which for females was the best predictor of mental and motor competency across age) is beginning to be linked to a different set of maternal behaviors, i.e., rapid maternal response to social behaviors. Possibly after this linkage of performance and environmental influences is established for males it will be possible to predict male competence from MI. Thus, it would be necessary to test this notion after a period of several months as it was possible from 2½ to 6 months for females.

Hypothesis IV: Clusters of variables relating to (a) maturation (Bwt, HI), (b) personality (SO and TO), and (c) maternal behaviors (OMLD, OMLV, MRD, MRS), will not be comparable correlates of competency for both sexes over time.

Correlates of Bwt/HI: To test Hypothesis 6(a), the correlations between variables representing possible maturational influences, Bwt, and HI were calculated and significant correlates are reported. The results of this analysis are contained in Table 17 for all subjects at 2½ and 6 months.

Table 17

Significant Correlates of Bwt and HI for All Subjects at 2½ and 6 Months

Variable	Bwt	HI (2½ Months)	HI (6 Months)
DI (1)	.277*		
MI (1)	.448**		
DI (2)			.318*
MI (2)			.316*
MRS (2)		.291*	

* .05 level of significance df = 49
** .01 level of significance

While Bwt correlates with DI and MI at 2½ months, it has no significant correlates at 6 months. HI at 2½ months is related to short maternal latency to respond to infant social behavior at the same age, while HI at 6 months is related to both DI and MI at the same age.

The Bwt/HI correlations for males are contained in Table 18, and Table 19 contains the correlations for females.

Table 18

Significant Correlates of Bwt and HI for Males at 2½ and 6 Months

Variable	Bwt	HI (2½ Months)	HI (6 Months)
MI (1)	.635**		
SO (1)		-.429*	
DI (2)	.415*		
HI (2)		.453*	--
OMLD (2)			.593**

* .05 level of significance
** .01 level of significance

df = 23

For males Bwt is related to MI at 2½ months and to DI at 6 months. HI is negatively related to SO at 2½ months indicating a relationship between rapid visual information processing and low social orientation. The habituation indexes are positively related over time indicating some stability

Table 19

Significant Correlates of Bwt and HI for Females at 2½ and 6 Months

Variable	Bwt	HI (2½ Months)	HI (6 Months)
DI (1)	.341*		
MI (1)	.346*		
MRS (1)		.405*	
DI (2)			.390*
SO (2)	-.395*		.351*
TO (2)			.379*

* .05 level of significance
** .01 level of significance
df = 24

in HI for males from 2½ to 6 months, and, at 6 months, HI is related to SO at 6 months. HI at 2½ months is related to short maternal latencies to respond to infant social behaviors at 2½ months. While HI for females shows no stability over time, HI at 6 months is related to other cognitive and personality variables (DI, SO, and TO). Therefore, while HI remains somewhat stable over time for males it is not significantly related to other infant behaviors at either time, and it begins to be related to maternal behavior at 6 months. Female HI is already related to maternal behavior at 2½ months, and by 6 months HI is related to other infant variables.

Here again, female measures of maturational variables are related earlier to maternal behaviors than is the case for males. This particular relationship between rapid information processing and rapid maternal response at 2½ months may be indicative of some mutual adaptation between infant and mother. Once this adaptation is established, the information processing skills of the female infant become related to other cognitive and social behaviors. This adaptation-generalization pattern may only be beginning to emerge for males at 6 months.

Correlates of SO/TO: a matrix containing SO/TO correlations within and across ages for all subjects is contained in Table 20. Table 21 contains the matrix for males, and Table 22 contains the matrix for females.

Table 20

SO/TO Correlations for All Subjects at 2½ and 6 Months

	SO (1)	TO (1)	SO (2)	TO (2)
SO (1)	--	.656**		.401**
TO (1)	.656**	--		
SO (2)			--	.533**
TO (2)	.401**		.533**	--

* .05 level of significance
** .01 level of significance

df = 49

While SO and TO are correlated for all subjects within each age period, SO at 2½ months is also related to TO at 6 months which may indicate that infants are first oriented socially and later their social orientation becomes related to task orientation during the first 6 months of life.

The SO/TO correlations for males (see Table 21) do not show the significant SO (1)--TO (2) correlations however the correlations for females (see Table 22) follow those reported for all subjects.

Table 21

SO/TO Correlations for Males at 2½ and 6 Months

	SO (1)	TO (1)	SO (2)	TO (2)
SO (1)	--	.608**		
TO (1)	.608**	--		
SO (2)			—	.612**
TO (2)			.612**	--

* .05 level of significance, ** .01 level of significance
df = 23

Table 22

SO/TO Correlations for Females at 2½ and 6 Months

	SO (1)	TO (1)	SO (2)	TO (2)
SO (1)	--	.694**		.429*
TO (1)	.694**	--		
SO (2)			--	.494**
TO (2)	.429*		.494**	

* .05 level of significance, ** .01 level of significance
df = 24

Again, females give evidence of a pattern of change that may predate the same pattern in males.

Tables 23 and 24 contain correlates of SO/TO for males and females respectively. For females at 2½ months, SO and TO are realted to maternal behaviors, i.e., SO is related to long maternal latency to respond to infant vocalizations, while TO is associated with short maternal latency to respond to infant distress behaviors. By 6 months high TO is associated with high MI at 2½ months. The early development of motor skills may be one way that the female infant is able to become task oriented by 6 months. The 6 month old female's SO and TO are also related to rapid visual information processing, while male TO at the same time is associated with long maternal latency to respond to infant social signals. This pattern of relationship between maternal behaviors and TO is one that seems to be established earlier for females than for males.

Table 23

Significant Correlates of SO/TO for Males
at 2½ and 6 Months n = 25

Variable	SO (1)	TO (1)	SO (2)	TO (2)
DI (1)		.756**		
MI (1)	.429*	.656**		
HI (1)	-.429			
MRS (2)				-.491*

* .05 level of significance
** .01 level of significance
df = 23

Table 24

Significant Correlates of SO/TO for Females
at 2½ and 6 Months N = 26

Variable	SO (1)	TO (1)	SO (2)	TO (2)
DI (1)	.465*	.666**		
MI (1)		.467*		.515**
Bwt			-.395*	
OMLV (1)	.383*			
MRD (1)		.512**		
DI (2)			.508**	.556**
HI (2)			.351*	.379*
MRS (2)				-.335

* .05 level of significance
** .01 level of significance
df = 24

Correlates of maternal variables: since maternal behaviors are important correlates of infant competence, these measures have been examined for internal consistency within age and stability across age for all subjects and then for males and females. Table 25 contains significant correlations for all subjects between maternal variables at 2½ and 6 months. The upper right and lower left quadrants of the table show across age relationships in maternal behaviors, while the upper left and lower right quadrants contain across age consistency. At 2½ months rated maternal latency to respond to infant distress and social behaviors

Table 25

Correlations of Maternal Variables for All Subjects at 2½ and 6 Months N = 51

Variable	MRS (1)	MRD (1)	OMLV (1)	OMLD (1)	MRS (2)	MRD (2)	OMLV (2)	OMLD (2)
MRS (1)	--	.495**			.397**			
MRD (1)	.495**	--			.291*	.362*		
OMLV (1)			--					
OMLD (1)				--				
MRS (2)	.397**	.291*			--			
MRD (2)		.362**				--		
OMLV (2)							--	
OMLD (2)								--

* .05 level of significance
** .01 level of significance

df = 49

are significantly correlated, but by 6 months these rated behaviors are not correlated for all subjects. The rated behaviors are also significantly related across time. The observed latencies (measured in seconds) are not significantly related to each other within time or across time.

Different patterns of maternal behaviors emerge for males (see Table 26) than for females (see Table 27). Maternal responses to male infants' distress and social behaviors are correlated at both 2½ and 6 months, indicating that mothers of males in this sample establish some consistent tempo of response to both distress and social infant behaviors, while for female infants maternal responses to distress and social behaviors are significantly correlated at 2½ months but are not significantly correlated by 6 months. This lack of relationship in maternal response to different female infant behaviors by 6 months may indicate that the mothers' responses to different female infant behaviors have become differentiated by 6 months (which is not the case for males).

Although it is not possible to determine causation of different maternal responses to males and females, it could be speculated that within the female-mother dyad, specific behaviors become more adaptive and more change occurs in the form of response differentiation. However, maternal

Table 26

Correlations of Maternal Variables for Males at 2½ and 6 Months N = 25

Variable	MRS (1)	MRD (1)	OMLV (1)	OMLD (1)	MRS (2)	MRD (2)	OMLV (2)	OMLD (2)
MRS (1)	--	.444*						
MRD (1)	.444*	--						
OMLV (1)			--					
OMLD (1)				--				
MRS (2)					--	.474*		
MRD (2)		.455*			.474&	--		
OMLV (2)							--	
OMLD (2)								--

Table 27

Correlations of Maternal Variables for Females at 2½ and 6 Months N = 26

Variable	MRS (1)	MRD (1)	OMLV (1)	OMLD (1)	MRS (2)	MRD (2)	OMLV (2)	OMLD (2)
MRS (1)	--	.556**			.509**			
MRD (1)	.556**	--			.354*			
OMLV (1)			--					
OMLD				--				
MRS (2)	.509**	.354*			--			
MRD (2)						--		
OMLV (2)							--	
OMLD (2)								--

responses to distress and social behaviors show consistency across time for mothers and their infant females while only response to distress is consistent across time for males and their mothers. The actual time that mothers take to respond to infant behaviors are not significantly related across or within time periods. Hypothesis 4 was confirmed.

Discussion

Validation of the model within age periods

The transactional model of infant competence that was developed from measures representing both infant and maternal characteristics did prove to be a significant predictor of independent criterion variables representing infant mental and motor competencies at 2½ and 6 months, thus confirming Hypothesis 1. This model of early infant competency was developed and tested using a restricted sampling of middle class, white, first born infants living in intact nuclear families where the mother was the primary caretaker. The infants were characterized as having birth weights within the normal range and as being free of significant birth defects. The generality of the model is limited by the limited range of background characteristics of the sample, and prediction is statistically limited by the restricted range of subjects used in this sample (Nunnally, 1967).

Within the model, the infant's own personality characteristic, task orientation, was the most useful predictor of infant competence at each age. The method used in this study for rating infant personality characteristics is analogous to that used by Birns and Golden (1972) with a black lower and middle class infants from 1 to 2 years of age. The method varied from that used by Birns and Golden to the extent that in the present study the task orientation dimension included "pleasure at task," and "attention, persistence," that Birns and Golden had rated separately. Another of their significant predictor variables, "cooperation" was included, for the purposes of this study, in the social orientation measure. The results of the present study provide at least partial answers to the questions raised by the findings of Birns and Golden (1973). It is possible to detect the pleasure at task dimensions of infant personality by the time the infant is 2½ months old. Task orientation is not particularly stable over time in early infancy, but rather, social orientation at 2½ months is related to task orientation at 6 months which may indicate a critical transition period for the infant relative to emerging competence. For example, the competent infant's "job description" may change within early infancy. The "job" or task of the competent 2½ month old may be one of establishing social linkages into the world of people (Brackbill, 1967; Rheingold et al, 1959), particularly caretakers. Once these social linkages are established, the competent 6 month old infant apparently directs attention toward problem solving in the world of objects. These findings complement those of Yarrow et al. (1971). Social orientation at 2½ months is not significantly related to measures of infant competence at 6 months except through its significant relationship to task orientation at 6 months which is the best single predictor of infant competence at that age. This pattern of relationships is more clear in early infancy for females than for males.

Birns and Golden (1973) further questioned whether pleasure in problem solving is intrinsic or modifiable, and what kinds of maternal behaviors foster or inhibit it? The present findings relative to maternal-child interaction would tend to support the notion that relatively longer maternal latency in response to infant social behaviors at 2½ months is related to high infant task orientation at 6 months, while short latency to respond to infant distress behaviors is associated with high task orientation at 2½ months only (and accounts for only about 10% of the variance in task orientation at that time.) What task oriented infants in this sample appear to get from their mothers is time to operate upon their environments that is not immediately interrupted by maternal behaviors. It would appear that task oriented behaviors are themselves inherently rewarding (Piaget, 1952), and the infant's, "smiling vocalizing, and reaching out to people; his visually attending to and manipulating objects tend to be self-reinforcing, and thus, to some extent, self perpetuating [Yarrow, et al, 1972, p. 217]." Mothers of high task oriented infants in this sample tended to be rated as less responsive to infant social behaviors which may indicate that for this particular group of infants, "intrinsic motivation seems best stimulated by allowing the child to engage in the activity of his choice for unbroken periods of time [Elkind, 1969, p. 187]."

An area that remains to be tested is the way in which the environment is presented to the infant in terms of the introduction of materials upon which he/she can operate. Possibly, by 6 months, variables which index the physical environment and the model of presentation of materials to the infant make up a major proportion of the variance that is not accounted for by the present model at that age. Yarrow et al. (1972) have found that features of the material environment are related to cognitively oriented infant behaviors at 5 and 6 months. Therefore, the decline in percentage of variance accounted for by the model used in this study between 2½ and 6 months may be related to dimensions of the inanimate environment that were not included in the model of infant competency. The model used in this study was far more adequate in predicting competence at 2½ than at 6 months.

Contributions of individual variables to the model:

The notion tested in Hypothesis 2 that each of the predictor variables chosen would account for some of the variance in infant mental and motor competence at 2½ and 6 months was only partially confirmed. While birth weight is related to infant mental and motor competence at 2½ months, by 6 months it is no longer a significant predictor for all subjects (however, the birth weight-competency relationship persists for males through 6 months). When birth weight drops out as a significant predictor at 6 months the habituation index becomes a significant predictor of mental and motor competence. While the infant's own personality characteristics, social and task orientation, are important predictors of mental development at both ages, by 6 months social orientation accounts for only 7% of the variance in motor development. One maternal behavior, observed long latency to respond to infant distress behaviors, is a significant predictor of motor competence at 2½ months, while long rated maternal latency to responsiveness to infant social and distress behaviors is significantly related to motor competence at 6 months.

Over time, different variables account for significant proportions of the variance in mental and motor competence, however, one variable, observed maternal latency to respond to infant vocalizations, contributed an insignificant proportion of the variance to mental and motor development at each age. This variable was included in the model because it represented a dimension of positive reinforcement of infant social behaviors. This dimension would fit the notion of the infant's receiving positive feedback from the environment because of his/her (social) actions. This variable which represents the infant's receiving immediate positive social feedback from the environment, when used in combination with other infant and maternal variables, does not not strengthen the efficacy notion of developing competence. The maternal behaviors that did predict infant competency involved long maternal latencies. For the observed latency measures, the 10 second time frames used for the recording of behaviors may be so short as to not represent an adequate differential measure of behavior which might affect the infant. The relatively longer latency may represent an optimal response delay rather than a true long latency, in terms of the infant's ability to process the information contained in the maternal response relative to his/her initiating behavior.

However, when the rated long maternal latency at 6 months confirmed the pattern established from the observational variable at 2½ months the notion that "hovering" possibly overly reactive maternal behavior, does not contribute to high motor competency becomes more clearly established.

"Hovering" maternal behavior may be indicative of a class of maternal attitudes and behaviors that would not promote or encourage infant competency, or allow the infant to use his own systems of adaptation. The interaction of one of the mother/infant dyads in the study may illustrate this type of "hovering" or smothering behavior. When the mother and infant came to the infant laboratory for the 6 month visit, the infant was completely unable to sit alone. It was observed that when the infant was held by the mother in an upright position, she was held so close to the mother that she was permitted no movement or adaptation of position on her own. When the infant evaluator demonstrated to the mother how the child might be held to permit her to adapt to the sitting position more independently, the infant quickly began to adjust to the sitting position using minimal supports. However, the smothering maternal behavior appeared to have already contributed to the delay of motor competency in the infant. The same type of inhibiting behavior may be accomplished by the mother who responds to infant signals before the infant has tried to adapt to the environment on its own. These findings support the notion that, "An environment which restricts . . . and even discourages the individual from attempting to attack and solve problems on his own is likely to retard development [Bloom, 1964, p. 77]."

Prediction of maternal response:

When the question was asked regarding what predicts long latent maternal responses, an infant characteristic, rather than the mother's own behavior, was the most significant predictor. Long latency of maternal response to the distress signals of infants who are high motor competent and of high birth weight, indicate that the infant's own characteristics differentially dictate maternal response. Fleener and Cairns (1970) have found that mothers are less responsive to the crying of older infants in a sample of infants from 3 to 19 lunar months of age. Possibly the mothers of high birth weight, motor competent infants in this sample perceived their infants as being "older" and therefore, responded as did the mothers of older infants in the Fleener and Cairns study.

The finding that an infant characteristic, motor competence, predicts maternal latency to distress points up influence of the infant's behavior on the mother's behavior in the interaction. Maternal responses to infant distress behaviors appear to become adaptive to different infant characteristics independent of the mother's established pattern of responses to other infant behaviors (Bell, 1971).

The validity of the model for across time prediction:

The notion, tested in Hypothesis 3, that a model of infant competence at 2½ months can predict an independent criterion at 6 months, was not confirmed. The 2½ month criterion of motor competence, alone, was significantly related to mental and motor competence at 6 months. This finding supports the theoretical position of Piaget (1952) that cognitive development proceeds from reflexive (motor) behavior in combination with neurological and physical maturation (Maier, 1969) to voluntary movement which constitutes the stage of "primary circular reaction" "Maturational readiness is requisite to this development [Maier, 1969, p. 105]." The primary circular reaction stage gives way to the stage of "secondary circular reaction" when schemas are developed from the uniting of voluntary motor activities into one sequence where vision becomes the primary mechanism (Maier, 1969) for coordinating sensori-motor activities. The new importance of visual information processing at this stage may account for the finding, in this study, that the habituation index becomes a predictor of mental and motor competence at 6 months. Secondary circular reactions can be described by indicating the several processes that are combined to form the following act:

> Visible fractions of an object can serve to trigger an action sequence. To illustrate, the sight of the end of a familiar string can be sufficient to induce

> a child to pull, perhaps to shake the carriage hood over his head. The string, the shaking, and the motion of the hood are one universe, . . . an action sequence contains the potential for many intellectual accomplishments. Most roots for future cognitive understanding are acquired during this early sensorimotor phase . . . [Maier, 1969, p. 108].

Thus, the motor readiness of the 2½ month olds in this sample appears to form the basis for mental and motor competence at 6 months. The competence model used in the present study contained no direct measure of motor competence, which may be its primary weakness as a model used to predict competence in early infancy over time.

Other changes in patterns of infant development and sex differences in these patterns may account for some of the other unexplained variance that is not accounted for in the model at 6 months that was accounted for at 2½ months.

Patterns of correlates of infant competence:

The findings, discussed at length in the results section, regarding different patterns and/or timing sequences for males and females can be briefly summarized:

1. The 2½ month motor index for all subjects in the sample is related to mental and motor competence at 6 months. However, when these correlations are calculated by sex,

a statistically significant relationship exists for females and not for males.

2. Birth weight is a significant correlate of mental and motor competence at 2½ months for all subjects, but continues as a significant correlate of mental competence at 6 months only for males.
3. The habituation index fails to correlate with other infant characteristics for all subjects at 2½ months, although at 6 months, it is a significant correlate for all subjects of mental and motor competence. The index is stable across time for males but not females.
4. Social orientation at 2½ months is significantly related to task orientation at 6 months, however, when analyzed by sex, the relationship for females between these variables is significant but not for males.
5. There was no consistency in observed latencies of maternal responses to infant vocal and distress behaviors within or across time.
6. Rated maternal responsiveness to infant distress and social behaviors are correlated across time periods for all subjects, however, when these measures are analyzed separately by sex, this relationship remains significant for females while only maternal response to distress is significantly related across time for males.

7. The 2½ month ratings of maternal response to infant distress and social behavior are significantly related to each other for all subjects, but these same ratings are not significantly related at 6 months. Females follow the same pattern found for all subjects while rated maternal responses to infant distress and social behaviors continue to be significantly related at 6 months for males.

The patterns of correlations for males and females indicate that the paths to competence may differ, but more importantly, the time at which patterns emerge is different for the males and females in this sample and, therefore, Hypothesis 4 was confirmed. These results support the notion expressed by McCall, et al.(1973) that patterns of relationships between I.Q. and other variables may vary as a function of age and sex.

The general pattern of relationships of variables with mental and motor competence changes over time for males and females in terms of their relationship to maturational characteristics and characteristics of the infant's environment. While males' mental and motor competence appear to be influenced at least through 6 months by initial physical status, this relationship for females is noted only at 2½ months. On the other hand, maternal characteristics are related to female infant competencies at 2½ months, a relationship that appears at 6 months for males. One finding that should be noted, however, is the initial influence on mental and motor competency of the infant's status at birth as indicated by birth weight. It appears that the infant who was able to profit from an enriched prenatal environment does indeed enter the world with some maturational advantages, even within this sample of normal birth weight infants. This finding provides support for the notion that, "It is possible that performance on infant tests is governed more closely by genetic and maturational factors that decline in influence with development [McCall et al., 1973, p. 15]." The change in the birth weight/mental and motor competency relationship for females between 2½ and 6 months may signal an earlier decline in the influence of "genetic and maturational factors" for the female than for the male infants in this sample. This decline in maturational influence is associated for females with the earlier rise of the influence of maternal behaviors on female infant competence. Males do not show evidence of this pattern change until 6 months, when competence measures become more linked to maternal behaviors. When male competencies become significantly related to maternal behaviors, the patterns differ somewhat from those established by females. While female motor competence at

2½ months is associated with long latent maternal response to distress behaviors, motor competence of males at 6 months is related to short latent maternal response to vocal social behaviors. Therefore, it is difficult to project from these data whether patterns for males emerge later than the same patterns for females, or if they are truly different. Nevertheless it should be noted that males do tend to lag behind females in the patterns of relationships of competency variables with environmental variables.

Conclusions:

The acquisition of early infant competence does indeed appear to involve the interplay of maturational/physical, personality, and environmental events, and therefore, cannot be assumed to come from the organism alone or from the environment alone. In early infancy, however, the infant's own characteristics appear to weigh very heavily in his/her transactions with the environment. While this relationship appears to lessen over time, another sampling of infant and maternal behaviors at a later time would be necessary to validate these emerging patterns. Female infants appear to "overcome" initial maturational influences and become adapted to the environment earlier than do males, however this does not exclude the possibility of differential attitudes and expectations and adaptive behaviors displayed by mothers of males and females. It appears that mothers of female infants differentiate their own pattern of responses to infant behaviors earlier than do the mothers of male infants. However, whether this is because the mothers of males and females have different expectations for their infants from the outset or because the female infants are more effective "teachers" of maternal behaviors remains to be answered.

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Social Orientation Rating Scale

These items have been compiled from some of those used in the Infant Behavior Record of the Bayley Scales of Infant Development (Bayley, 1969).

1. Responsiveness to persons (Circle one):

    1 Behavior towards persons is not different from behavior towards objects

    2 Between 1 and 3

    3 Responds briefly to social approach but when not approached directly by persons does not attend to them

    4 Between 3 and 5

    5 Responds to social approach and persons present, but less than half the time

    6 Between 5 and 7

    7 Responds to social approach and continues interest in persons present

    8 Between 7 and 9

    9 Behavior seems to be continuously affected by awareness of person present

2. Responsiveness to examiner (Circle one):

    1 Avoiding or withdrawn

    2 Hesitant

    3 Friendly

    4 Inviting (initiating, demanding)

3. Responsiveness to mother (circle one):
   1 Avoiding or withdrawn
   2 Hesitant
   3 Accepting
   4 Friendly
   5 Inviting (initiating, demanding)
4. Cooperation with examiner, based on interpersonal reactions (Circle one):
   1 Resists all suggestions or requests
   2 Does not cooperate
   3 Refuses or resists one or two specific tests, or refuses to cooperate during part of the session (e.g., initially, or towards the end), or refuses to attempt the more difficult items he is likely to fail
   4 Between 3 and 5
   5 Responds to or accepts the test materials or situation; neither cooperative nor resistant in relation to examiner
   6 Between 5 and 7
   7 Seems to enjoy the give-and-take with the examiner in the testing situation
   8 Between 7 and 9
   9 Very readily and enthusiastically enters into suggested games or tasks

Task Orientation Rating Scale

These items have been selected from those used in the Infant Behavior Record of the Bayley Scales of Infant Development (Bayley, 1969).

1. Responsiveness to objects; toys or test materials (Circle one):
    1 Does not look at or in any way indicate interest in objects
    2 Between 1 and 3
    3 When given materials, glances at them and holds them briefly but does not exploit them
    4 Between 3 and 5
    5 Plays with materials when presented; discards or loses interest in each after a brief reaction
    6 Between 5 and 7
    7 Sustained interest in the test materials, in each new one in turn as presented
    8 Between 7 and 9
    9 Reluctantly relinquishes test materials
2. Persistence in goal-directed effort (Circle one):
    1 No evidence of directed effort
    2 Between 1 and 3
    3 Makes a few attempts at a goal, but is easily distracted or does not show interest in carrying to completion (e.g., attaining an object, solving a problem)

4 Between 3 and 5

5 Makes fairly persistent efforts towards a goal, or repeated attempts to achieve a goal (e.g., to attain an object of interest)

6 Between 5 and 7

7 Persistent efforts to reach goal or solve a problem

8 Between 7 and 9

9 Compulsive absorption with a task until it is solved

3. Tendency to persist in attending to any one object, person, or activity, aside from attaining a goal (Circle one):

1 Fleeting attention span

2 Between 1 and 3

3 Attends to a toy, task or person, but is easily distracted

4 Between 3 and 5

5 Moderate attention to each new toy, person, or situation; soon ready for another

6 Between 5 and 7

7 Continues interest in persons, tasks or things for rather long periods

8 Between 7 and 9

9 Long-continued absorption in a toy, activity or person

4. Behavior constance in adequacy of response to demands of the tests (Circle one):

1 Tires easily; quickly regresses to lower levels of functioning

2 Between 1 and 3

3 Grows restless fairly soon and terminates the test situation

4 Between 3 and 5

5 Adequate tolerance for most of the test; only restless towards the end

6 Between 5 and 7

7 Holds up well throughout testing

8 Between 7 and 9

9 Continues to respond well and with interest, even during prolonged tests at difficult levels

Appendix C

Maternal Rating of Response to Distress

Latency of Maternal Response to Distress MRD Scale (This scale is a modification of one developed originally by Frank A. Pedersen, Ph.D., National Institute of Child Health and Human Development, 1972).

The scale rates the extent to which the mother responds quickly to infant distress signals. Rating takes into consideration the amount of time before the mother gives a direct response, and the intensity of the infant's signal.

0 Not applicable: Infant manifests no distress or others respond instead of mother.

1 Very long latency: Mother ignores baby's intense distress signal or may wait several minutes before she makes some attempt to respond to it. She may verbally acknowledge baby's distress at a distance.

2 Long Latency: Mother usually does not respond to baby's intense distress signal for one or two minutes or if baby is fussing may wait for several minutes.

3 Moderate latency: Mother usually responds quickly to an intense cry and within a couple of minutes of fussing or whining. At times her involvement in other activities may prevent her immediate response to infant's distress signal.

4 Short latency: Mother usually responds almost immediately to fussing or whining.

5 Very short latency: Mother consistently responds quickly or directly to minimal cues, e.g., increased motor activity, change to mouthing or finger sucking.

Appendix D

Maternal Rating of Response to Social Behavior

Rated Maternal Sensitivity and Responsiveness to Positive Social Behaviors (MRS) Scale

(This scale is a modification of one developed originally by Frank A. Pedersen, Ph.D., National Institute of Child Health and Human Development, 1972.)

This scale rates the degree to which the mother responds to such infant behaviors as vocalizations, visual attentiveness and smiles as social signals, or increase or decrease in activity to a social stimulus. The low point on the scale would involve ignoring such behavior. The high point would represent extreme sensitivity to such behavior and treating the behavior as a meaningful social signal. Maternal response to the infant's behavior may run the range from acknowledgement to estatic pleasure accompanied by all manner of "social reinforcement," including pats, hugs, smiles, verbal praise, positive affect, etc.

Maternal responses are rated on the following scale:

1 Very low responsiveness: Occasional response to obvious social signals (infant visual attention, vocalizations and smiles, tugs, etc.).

2 Low responsiveness: The mother notices the infant's more obvious positive social behavior and consistently is responsive to it. When the infant vocalizes or looks at her face, she characteristically reciprocates; she may smile or verbalize to the baby and on occasion

be more exuberant. She usually responds to obvious cues and occasionally to some subtle or emergent cues.

3 Moderate responsiveness: Consistently responds to obvious cues and frequently to emergent or subtle social cues.

4 Moderately high responsiveness: Consistently responds to both obvious and subtle social cues.

5 Very high responsiveness: The mother consistently and enthusiastically responds to the infant's every little nuance of behavior. She responds to both obvious and very subtle social cues of the infant.